NUCLEAR ENERGY

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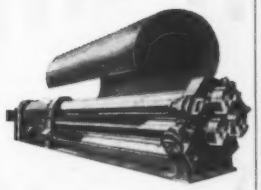

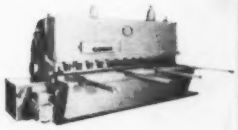

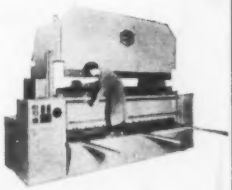

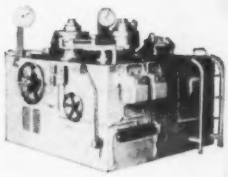

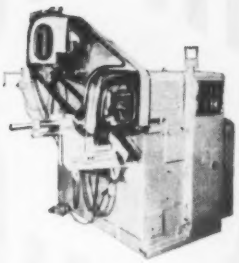

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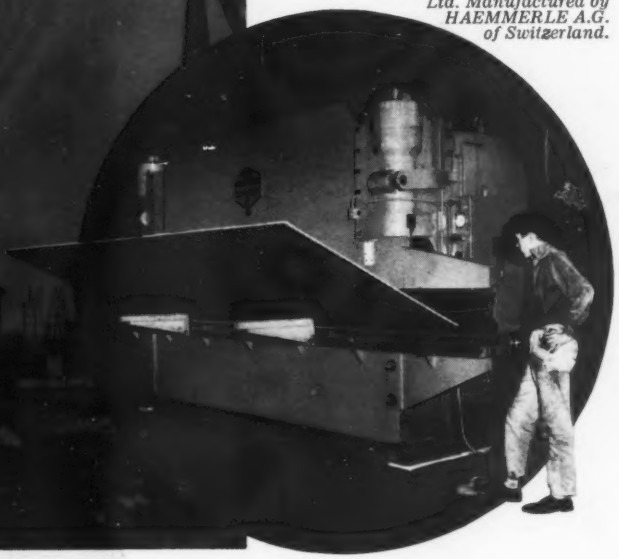

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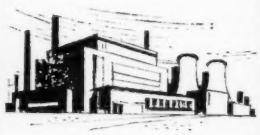

HINKLEY POINT

C.E.G.B. NUCLEAR POWER STATION

At Hinkley Point, Newalls have been entrusted with the insulation of the reactors, steam raising units, gas ducting, integral piping, etc., under contract to Babcock and Wilcox Ltd.

CHAPELCROSS

U.K.A.E.A. NUCLEAR POWER STATION

Under contract to Babcock and Wilcox Ltd., Newalls have carried out the insulation of the 16 steam raising units and integral piping. The insulation of turbines, blowers, associated auxiliary equipment and piping has been carried out under contract to C. A. Parsons and Co. Ltd.

BRADWELL

C.E.G.B. NUCLEAR POWER STATION

At Bradwell-on-Sea a further large contract for the thermal insulation of turbines, associated auxiliary equipment and piping (main and auxiliary turbine plants) has also been placed by C. A. Parsons and Co. Ltd. with Newalls.

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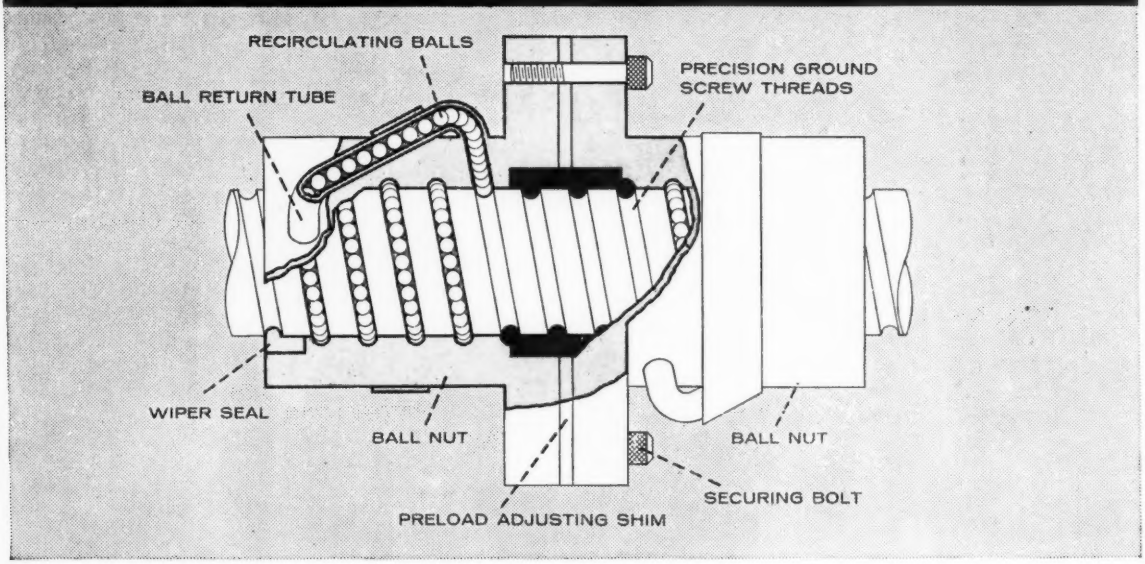

. . . ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

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Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

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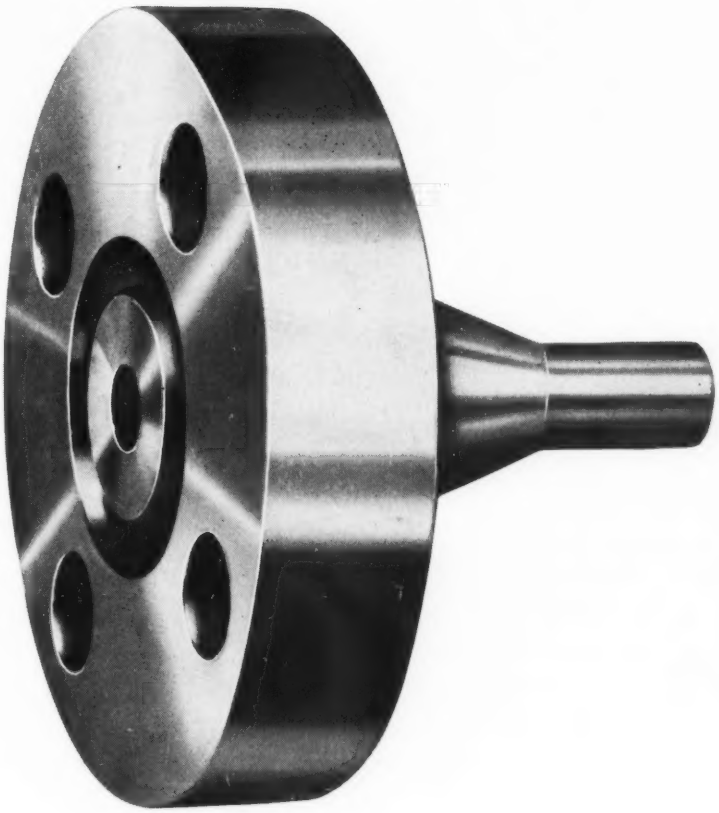

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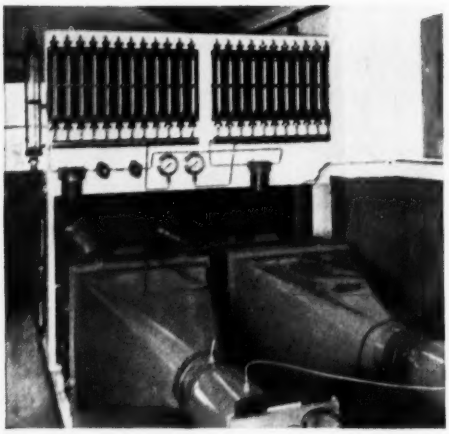

Vokes High Temperature 'Absolute' filters are tested in accordance with BSS. 2831 on the methylene blue test rig illustrated above. Every filter is subjected to a stream of air containing particles of methylene blue 'dust' ranging in size from 0·1 to 0·5 microns, and rejected if its efficiency is less than 99·99%. Vokes is the only British company which *guarantees* minimum performance figures in this way and Vokes filters are therefore widely used in all applications which require *scientific* filtration.

These filters have been designed for applications involving very high temperatures or risk of fire—for example in nuclear power stations where a breakdown in the filtration system due to an outbreak of fire might release dangerous toxic particles into the atmosphere.

They will withstand temperatures up to 1,000 F and are available in standard sizes as manufactured for the Atomic Energy Authorities. Similar in appearance to the 55 'Absolute' panels from which they were developed, Vokes high temperature filters have an all-glass paper filter medium with aluminium separators, refractory sealers and metal frames. The efficiency of this type of 'Absolute' is even greater than the very successful '55' panel, giving a penetration of only 0·01% against a methylene blue dust cloud.

A booklet on Vokes special purpose air filters is available on request.

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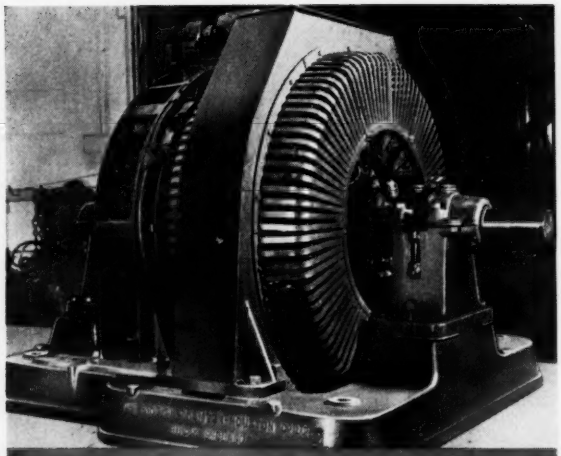
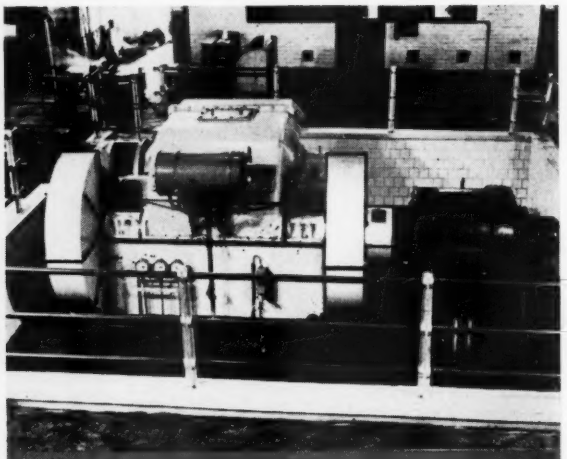


270/67.5 h.p. COMMUTATOR MOTOR, speed 375/95 r.p.m.



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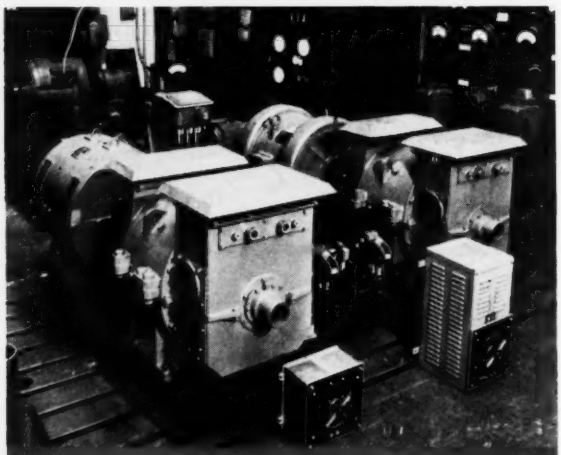

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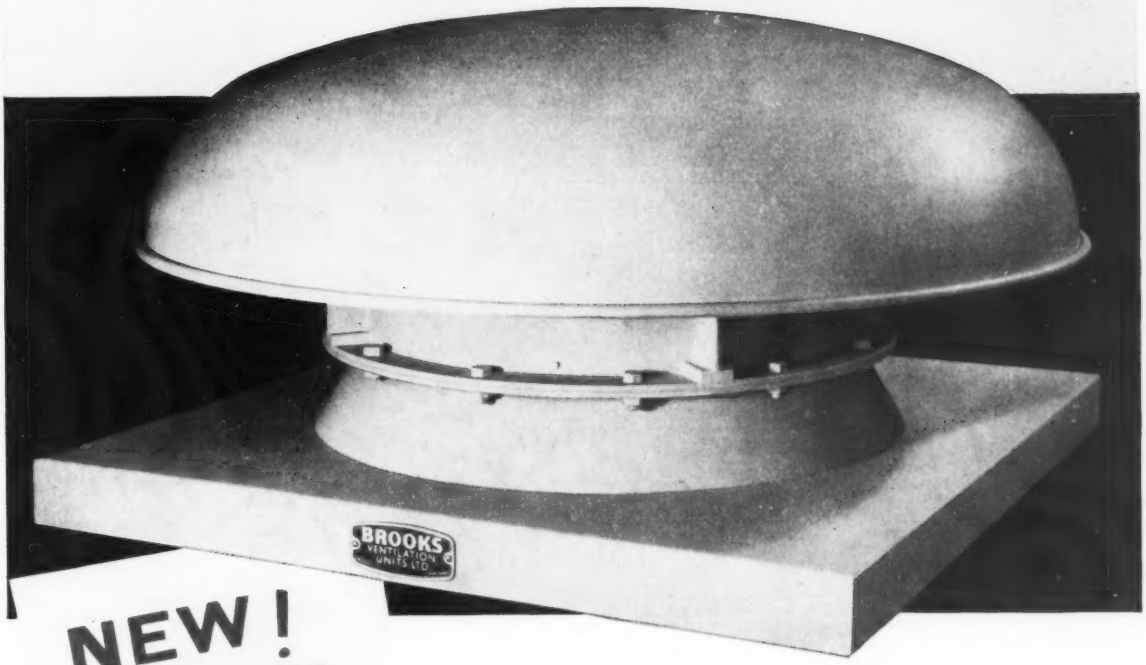

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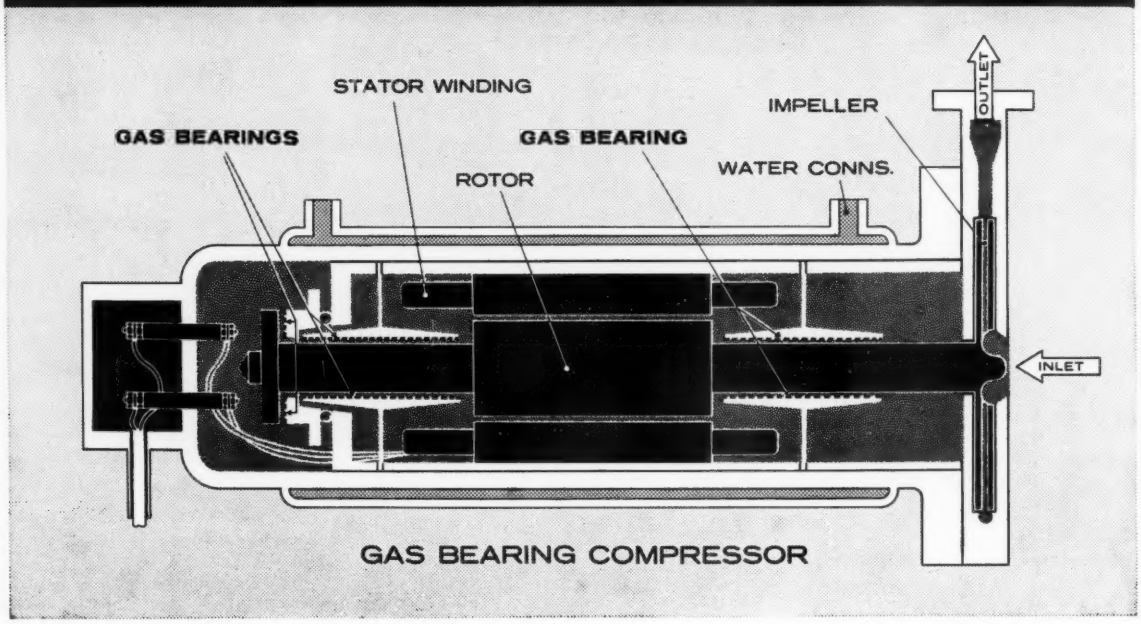

...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce gas bearing compressors. The design range covers a very wide performance capacity, from 0°–700° C gas operating temperature, 15–2,000 psi and 0.5–2,000-hp power input.

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Gas bearings have several great advantages over oil-lubricated bearings: the load-carrying capacity increases with speed, temperature and pressure; the bearings are supported on a film of the gas which is being circulated in the system, so there is no metal-to-metal contact under operating conditions and wear and maintenance are reduced to an absolute minimum; perfect cleanliness is preserved at all times.

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Bristol Siddeley gas bearings were developed originally to meet the extremely fine limits of operating purity and precision of nuclear engineering. But gas bearings have many other applications where a rotating shaft must be supported in such a way that no contamination and leakage can be allowed and where the supply of chemically pure fluids or gases is essential: in the textile, chemical engineering, pharmaceutical, food storage and processing industries, to name but a few. Bristol Siddeley produce a wider range of gas bearings than any other manufacturer and have the greatest experience in their design and application.

For further information please write to H. J. Prince, Sales Manager, Reactor Components Division, Bristol Siddeley Engines Limited, PO Box 17, Coventry.

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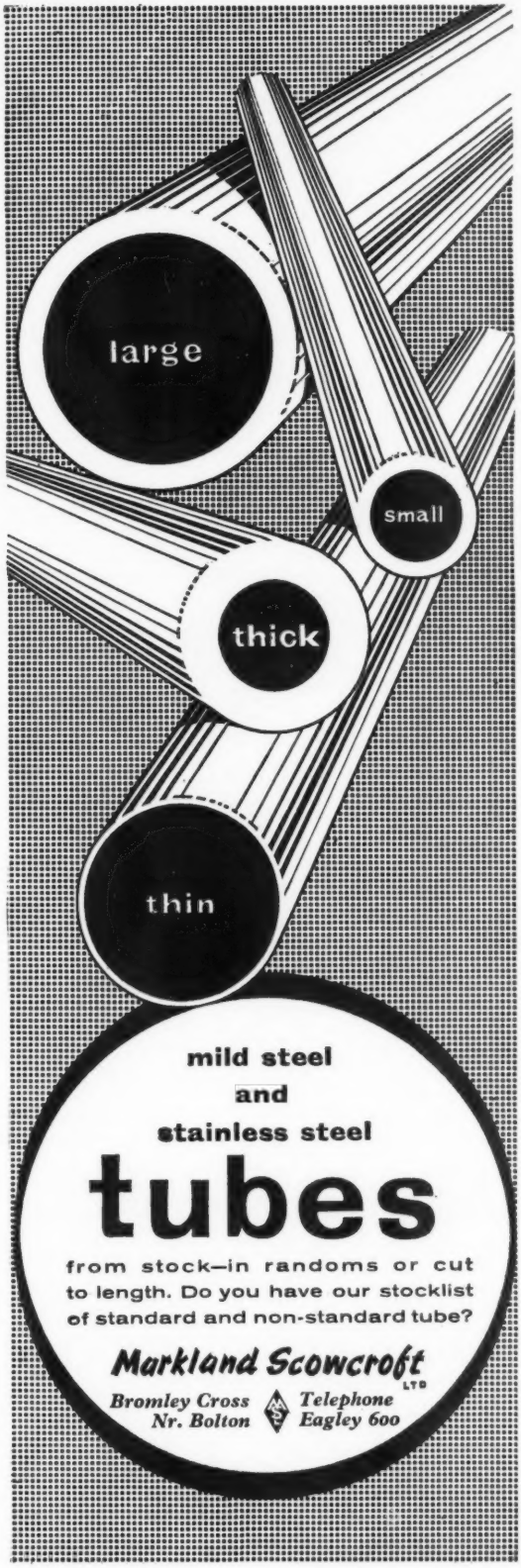

NUCLEAR ENERGY

JULY, 1960

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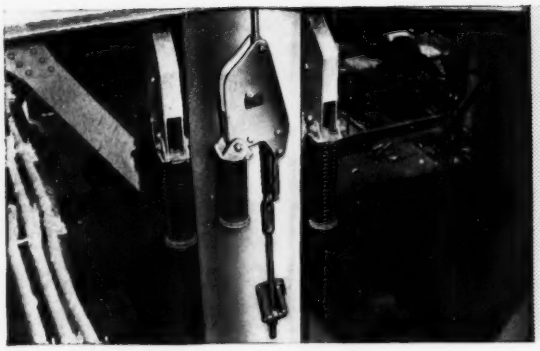

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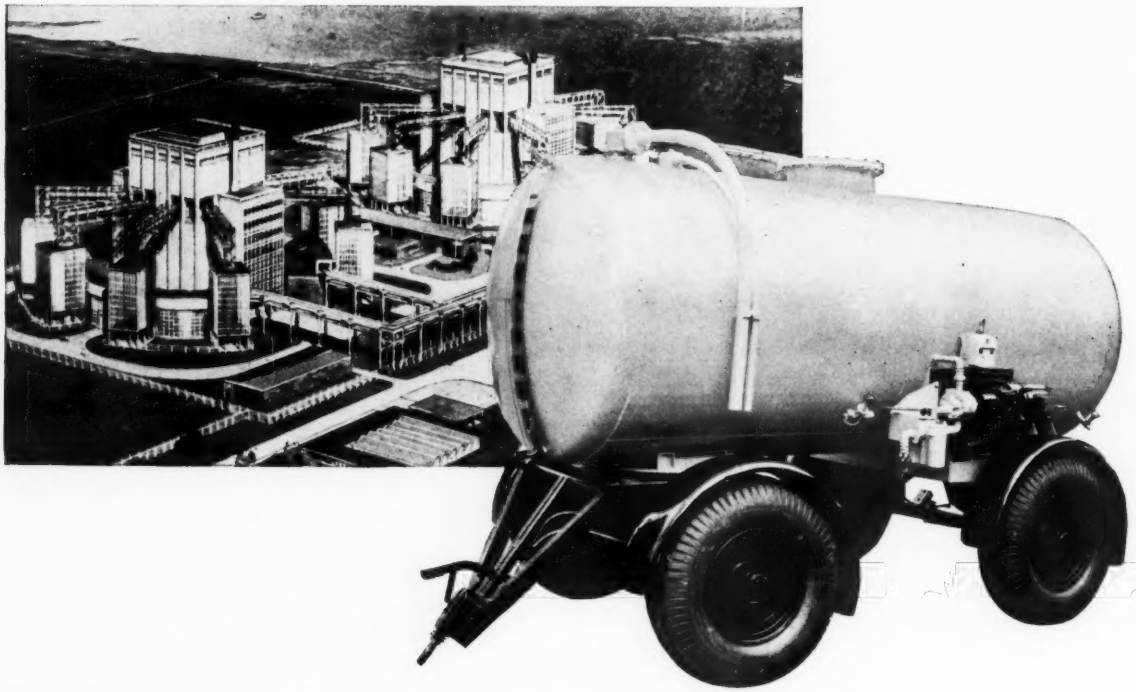


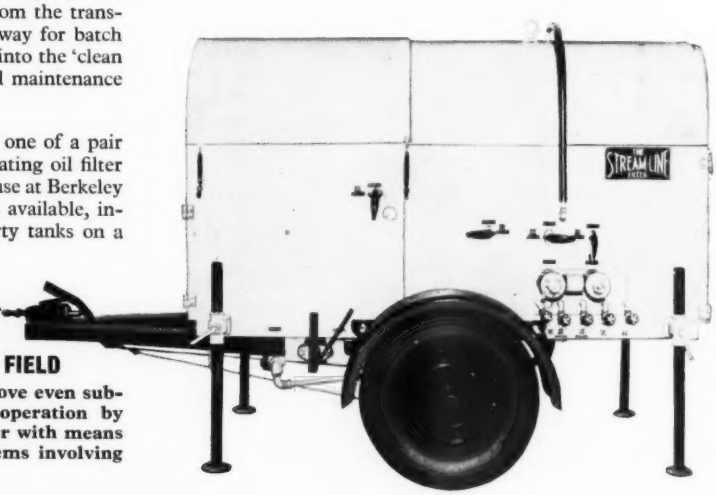
STREAM-LINE mobile filtration plant

To meet the special demands of maintenance engineers in nuclear power and similar applications, Stream-Line now supplement their range of insulating oil purifiers by the addition of large capacity mobile tanks. The Stream-Line filter is already well known for its efficiency in keeping insulating oil free from all solid, liquid and gaseous impurities; now, combined with two tanks (one for dirty, one for clean oil) it makes possible a completely mobile, extremely versatile filtration plant. Oil can be pumped quickly from the transformer into the 'dirty' tank and either taken away for batch filtration or filtered on site and passed straight into the 'clean tank'. While the oil is being purified essential maintenance work can be carried out on the transformers.

The 1,000 gallon tank illustrated above is one of a pair supplied with a 250 g.p.h. Stream-Line insulating oil filter to the British Thomson-Houston Co. Ltd., for use at Berkeley Power Station. Larger capacity tanks are also available, including models which combine clean and dirty tanks on a single transporter.

SUPER EFFICIENCY

For applications demanding super efficiency in the elimination of last traces of air and water, Stream-Line high vacuum filters (Type CN-HV) are available operating at pressures in the order of 0.1 mm. Hg., compared with the 28″/29″ Hg. vacuum employed by medium vacuum (CN) types. Outputs range from 50 to 1,500 g.p.h.



OTHER APPLICATIONS IN THE NUCLEAR FIELD

The ability of the Stream-Line filter to remove even submicronic particles, coupled with ease of operation by remote control, provides the nuclear engineer with means for dealing with some of his special problems involving radio-active materials.

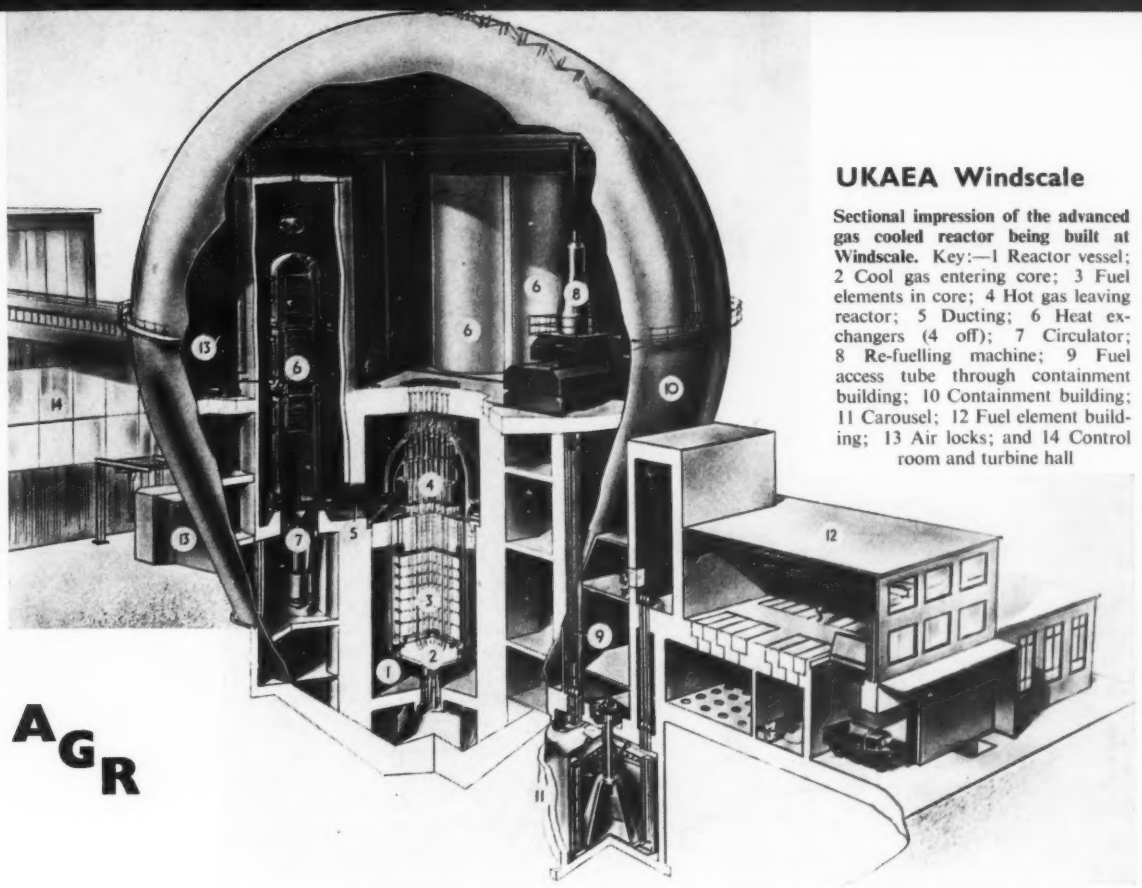
STREAM-LINE

STREAM-LINE FILTERS LIMITED
HENLEY PARK, NORMANDY, NR. GUILDFORD, SURREY

Telephone: Normandy 3311-3 Telegrams: Edgefilt, Guildford

A member of the VOKES Group

SF108



UKAEA Windscale

Sectional impression of the advanced gas cooled reactor being built at Windscale. Key:—1 Reactor vessel; 2 Cool gas entering core; 3 Fuel elements in core; 4 Hot gas leaving reactor; 5 Ducting; 6 Heat exchangers (4 off); 7 Circulator; 8 Re-fuelling machine; 9 Fuel access tube through containment building; 10 Containment building; 11 Carousel; 12 Fuel element building; 13 Air locks; and 14 Control room and turbine hall

The PROTOTYPE of New Type N-Stations

THE Advanced Gas-cooled Reactor plant being built at Windscale is the prototype of a series of nuclear stations which the Atomic Energy Authority are confident will produce in 1970 electricity at a price competitive with that from conventional fuelled stations. Basically it is a direct successor to the Calder Hall and current Magnox type of plant but it is so designed to produce more heat per ton of uranium. This will be achieved through the use of ceramic uranium oxide as fuel and either beryllium or stainless steel as the canning material.

Ready by next Spring

The AGR, as the prototype is called, is scheduled for completion by April, 1961. It will be used for solving problems associated with an advanced reactor type and for proving the feasibility of this particular design for larger stations. It will have a design heat output of 100 MW, which will be utilized to operate a 33 MW turbo-alternator.

Five loop systems will be incorporated into the reactor for testing fuel elements under more varied and advanced conditions than will be possible in the reactor proper. This will enable an operational lead to be obtained on their performance.

How Costs are Reduced

Over one-third of the cost of electricity generated in the present nuclear power station is contributed by the capital cost of the nuclear components. There is, therefore, great potential for reducing the cost of electricity by reduction of these capital costs. There are two obvious ways of bringing this about:—

(1) By an increase in the rating of the fuel. This increases the output per unit volume and hence decreases the size of the reactor core, the reactor pressure vessel, the biological shielding and the associated buildings. The reduction in the size of the reactor vessel also enables a greater pressure to be used for a given shell thickness—this enhances the heat transfer performance of the fuel elements and the heat exchanger and reduces the fraction of the power used to circulate the coolant gas.

(2) By an increase in the coolant outlet temperature from the reactor thereby increasing the thermodynamic efficiency of the steam cycle and enabling a reactor of smaller heat output to be built for the same electrical output. This increase in the temperature is brought about by increasing the fuel element surface temperature and, to a smaller extent, by the enhanced heat transfer performance arising from the increase in pressure.

The advanced nature of the AGR is clearly seen from Table 1 (overleaf) in which the rating and temperatures are compared with Calder Hall and the Magnox civil stations.

The outlet coolant temperature on AGR would permit with an optimized power reactor the adoption of a modern turbo-alternator, giving a net station efficiency of over 38 per cent. This compares favourably with the 25-30 per cent. attainable with the Magnox stations and gives an increase of almost one half in the electrical output of the station for the same reactor heat output.

To achieve the higher gas coolant temperatures, the fuel for the AGR will be formed into small diameter fuel elements mounted into clusters within 5 in. diameter graphite sleeves. Eighty per cent. of the elements will be clad with beryllium, and the rest with stainless steel. The uranium oxide within the elements will be in the form of pellets of the same thickness as diameter.

The Fuel Elements

The beryllium elements will be 0.3 in. in diameter and 12 in. long. Each cluster will contain 36 of them and there will be three clusters to each graphite sleeve. There will be 253 channels in the core and each channel will hold four graphite sleeves, which will be joined together.

The stainless steel elements will be 0.4 in. in diameter and 18 in. long. There will be 21 elements to each cluster and two clusters to each graphite sleeve.

Nominal maximum can temperature of the beryllium fuel assemblies will be 600°C., and of the stainless steel assemblies, 650°C.

Expected burn-up of the fuel is 10,000 MWD/tonne (peak).

In addition to utilizing a new fuel concept the AGR will contain several novel constructional and operational features. These will include, for instance, a neutron shield inside the reactor vessel so as to enable scientists and engineers to enter the vessel even after it has been put into operation, co-planar support of the reactor vessel and heat exchangers so as to eliminate vertical expansion problems and the adoption of the re-entrant principle of gas flow in through the vessel and core.

Three Parts to Plant

There are three main parts to the plant—the reactor unit housed in a containment vessel, the fuel element building and a turbine hall. The fuel element building contains the clean fuel element store and facilities for the breakdown and inspection of irradiated fuel.

Between the fuel element building and reactor building situated below ground level is a rotary store, or carousel, for holding irradiated fuel. It is gas-cooled. This method of storing spent fuels has been chosen in preference to the usual pond system in order to prevent problems arising from water corrosion.

The reactor unit is made up of a 53 ft 6 in. high cylindrical pressure vessel, four 68 ft high, 11 ft diameter heat exchangers and a refuelling machine. These are contained within a 134 ft tall pear-shaped building which is designed to hold all radioactive and noxious products that might be released in the event of any rupture or other damage to the reactor components.

The building, which has a maximum diameter of 135 ft, is supported on a concrete raft 99 ft in diameter, 8 ft thick and 4,000 tons in weight.

The Pressure Vessel

The reactor vessel is designed for a working pressure of 270 lb/sq.in. gauge and inlet temperatures of 250-325°C. and outlet temperatures of 500-575°C. It consists of a 21 ft diameter cylinder with hemispherical ends giving an overall height of 60 ft. The barrel is fabricated from $2\frac{7}{8}$ in. thick plate, the top end from $3\frac{7}{8}$ in. plate and some certain other parts from $4\frac{3}{8}$ in. plate. It is lined along the barrel by a 6 in. thick mild steel thermal shield. There are 253 branches in the top dome, each corresponding to a channel in the core and they are arranged on a $10\frac{3}{4}$ in. triangular lattice pitch.

The core, measuring 18 ft 4 in. diameter × 18 ft, rests at the bottom of the vessel on a diagrid. Above this is the neutron shield and at the top of the barrel is a hot gas collector box. The high temperature of the outlet flow of gas makes it necessary to prevent the gas from touching the inside of the pressure vessel and so it is collected in this special collector before being fed out of the vessel and into the heat exchangers.

Table 1.—Comparison of Ratings of different Reactors

	Calder Hall	*Magnox Reactors*	*AGR*
Maximum fuel rating (MW/tonne Uranium)	3	4–5.5	19.5
Inlet coolant temperature (°C.)	140	160–200	250–325
Outlet coolant temperature (°C.)	336	345–400	500–575
Coolant pressure (lb/sq.in. gauge)	100	125–240	270

As in the reactor vessel flow of the hot gas in the heat exchangers is upwards, resulting in the economizer being at the top. This method is of advantage to the natural circulation of the coolant in the event of a failure of the main circulators.

Coolant gas re-enters the reactor vessel through the top of the vessel and then makes its way to the bottom of the core via two main routes. Part of it flows down the inner wall of the vessel to help to keep its temperature down and the rest flows through the graphite bricks of the core.

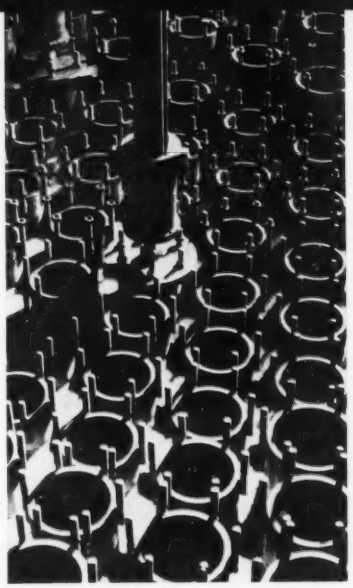
Refuelling of AGR

The reactor is refuelled on load. The single refuelling machine has two facilities mounted on a crab and gantry structure giving complete coverage of the refuelling face. The normal facility is for refuelling on load and at pressure. The special facility permits emergency functions to be carried out with the reactor off and depressurized. The machine also removes or replaces control rods and mechanisms and emergency shutdown devices and graphite sampling equipment.

Control of the reactor is achieved in a conventional manner by boron steel rods. Secondary shut-down devices are provided for the use in an emergency in the form of boron steel balls.

The reactor will be fitted with five experimental loop systems. These will consist of tubes which pass right through the core and which are sealed from the main coolant circuit at each end of the reactor vessel. They each have a completely separate coolant circulation and heat removal system which will be housed immediately outboard of the biological shield at basement level.

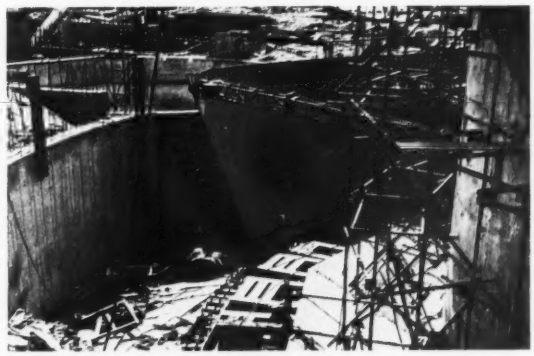
Each loop is contained in a separate cell forming an extension to the inner containment. They are designed to enable advanced experiments to be carried out which may, in some cases, result in coolant contamination with fission products which would be undesirable in the main coolant circuit.



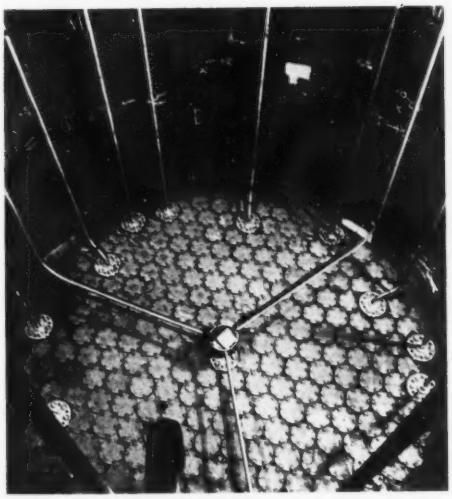
There will be 253 channels in the core of the AGR and each one will have access to the outside of the pressure reactor vessel through its own standpipe. Some of the pipes are seen here from inside the vessel. (*Below*) Erection of the first course of the reactor containment vessel is shown

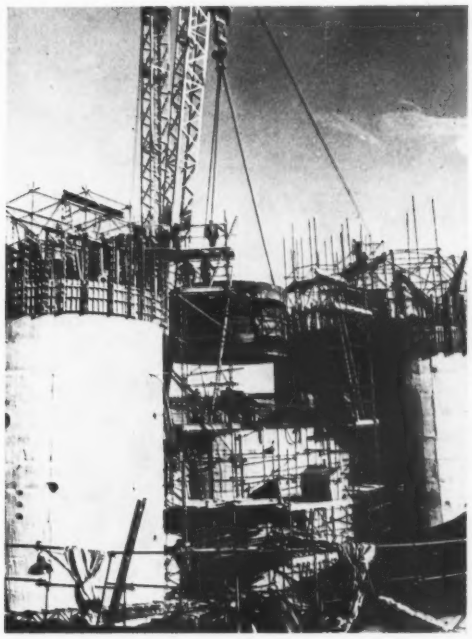
UKAEA Windscale

AGR Construction Progress



(*Above*) General view of the AGR plant. To the right of the circular containment vessel is the fuel element handling building in which clean fuel will be stored and spent fuel examined before being sent to the fuel examination laboratory under construction in an old blower house. To the left is the turbine hall. (*Bottom, left*) Inside the reactor vessel, looking downwards, showing the heater rods installed for stress relieving. (*Bottom, right*) One of the cylindrical sections of the pressure vessel being lifted into its position inside the biological shield. In the foreground is a partly completed heat exchanger shield





UKAEA Windscale

HERO—Complement to AGR

ONE of the prime functions of the AGR is to assess behaviour and life of the fuel elements at high neutron flux and temperature. Of equal importance to the development and optimization of an AGR type civil station is the study of the reactor physics of the system. Thus, a reactor for physics study is required having inherent flexibility of operating conditions and also a low neutron flux.

Pu Fuel Tests Later

HERO (Hot Experimental Reactor—ZERO energy), having a similar graphite core and enriched uranium oxide fuel elements to AGR is therefore being built to provide a suitable high temperature reactor in which the physics of the AGR system may be studied. It will also be used to study other graphite moderated core arrangements and among future investigations already planned is the study of the use of plutonium fuel elements.

The graphite core containing the fuel elements is housed in a steel vessel and heated by a flow of carbon dioxide. Coolant gas flow is maintained by means of circulators and heat is supplied by electrical heaters, both circulators and heaters, together with a heat exchanger and cooler, being housed in external circuits attached to the vessel. Fuel may be charged and discharged through standpipes in the top of the vessel, on which reactor equipment is also mounted. The whole of the reactor and its associated plant is housed in an enclosed concrete building forming a secondary containment. This building is situated at the end of one of the blower houses attached to the closed down Windscale pile.

In order that HERO may be complementary to AGR the graphite has been designed as a geometrical reproduction of the AGR core, having the same fuel element lattice pitch and channel diameter.

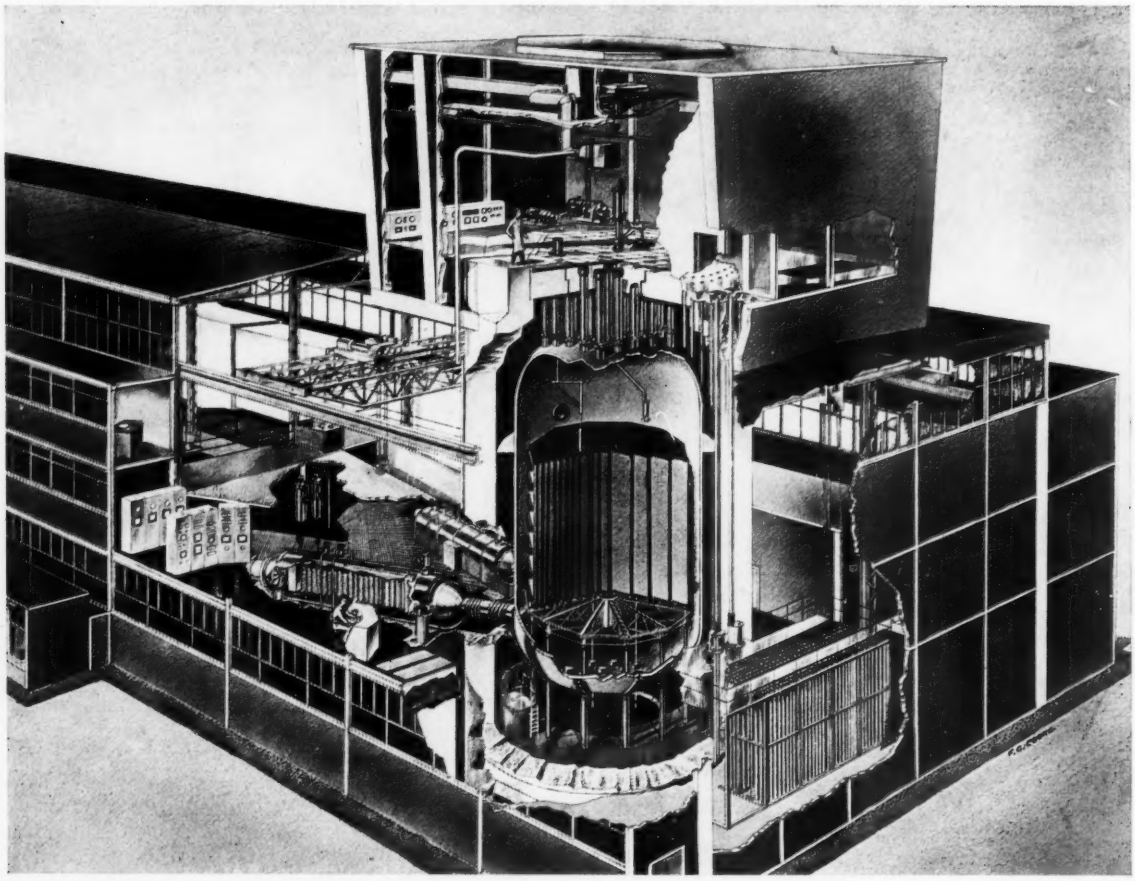
Preliminary Experiments

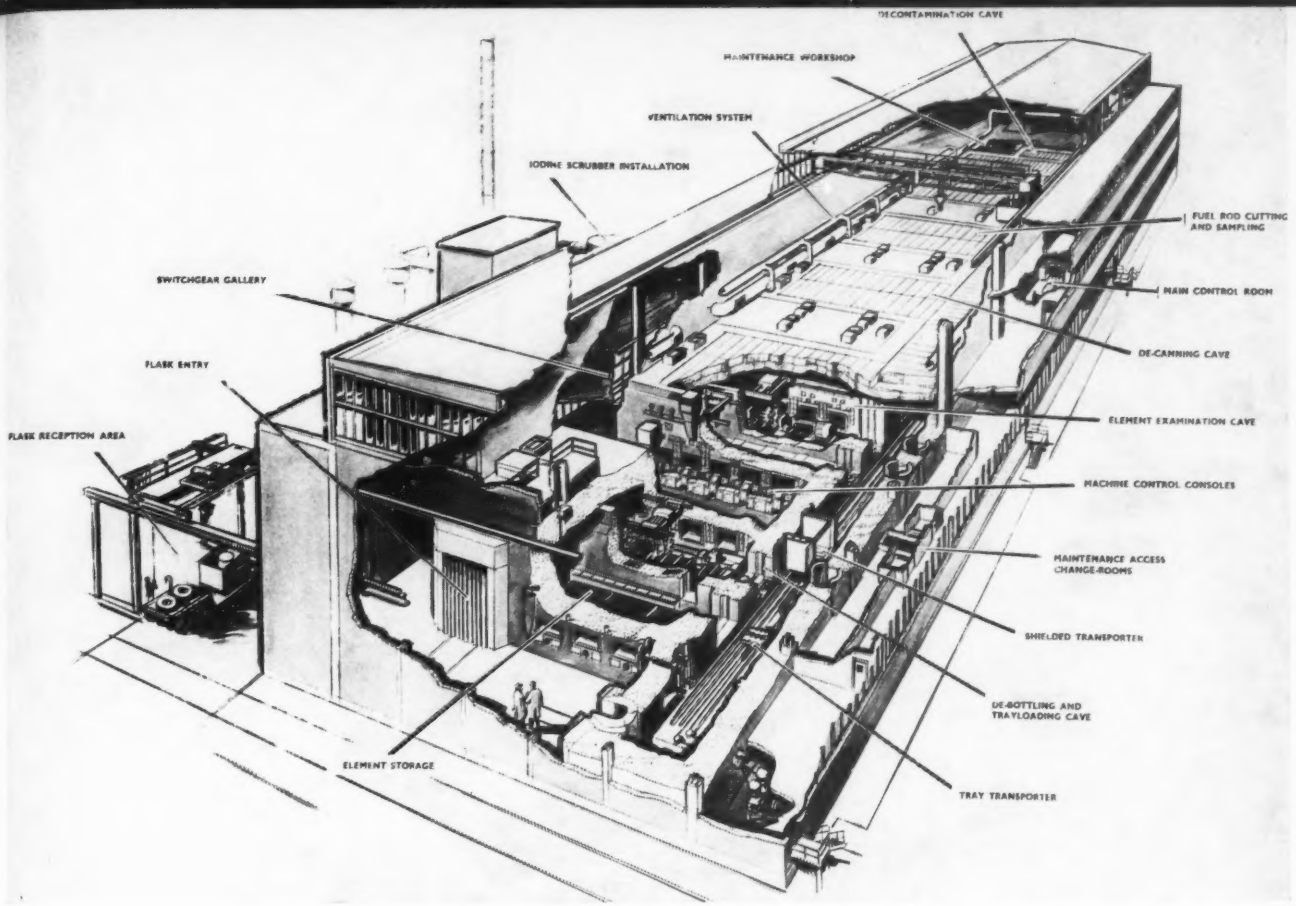
To assist in the start-up of HERO and AGR, several experimental facilities are being built adjacent to the HERO building. One of these has, in fact, already been completed and is in operation. It is an exponential stack. It is a small part of a reactor core driven by neutron sources located in the base and is being used for preliminary experiments in anticipation of the work to be done with the "approach to critical" stack.

This stack is an exact replica of part of the AGR core and will be used to provide information on the effects of loading fuel, control rods and absorbers so as to enable accurate start-up of HERO and AGR. It will also be used for the measurement of the constants of the AGR core to check the validity of the current method of calculation.

A third facility will be the "fine structure" stack, which is also similar to part of the AGR core but because of its physical dimensions is considerably below critical size. By siting really powerful neutron sources in the base it will be possible to make detailed measurement of the distribution of neutrons near fuel elements and within the graphite moderator so as to assist in calculating the power that will be generated in the reactor.

(*Below*) **Cutaway impression of HERO**





Cutaway impression of the fuel and examination laboratory being built in disused blower house of Windscale pile plant.

Fuel Handling and Examination

IN order to improve fuel element design and to establish where and why failures occur in existing designs it is necessary to examine fuel elements after they have been irradiated. Extensive facilities for such examination are being built at Windscale in conjunction with the AGR project.

The AGR fuel elements consist of rods of either beryllium or stainless steel-canned uranium oxide mounted in clusters inside a graphite sleeve. There are four sleeves to each fuel channel in the core and they are linked together to form what is called a stringer.

It is expected that one or two stringers a week will be selected for examination. After a cooling period in the carousel situated between the reactor building and fuel element building, the selected stringers will be delivered to a special dismantling cave.

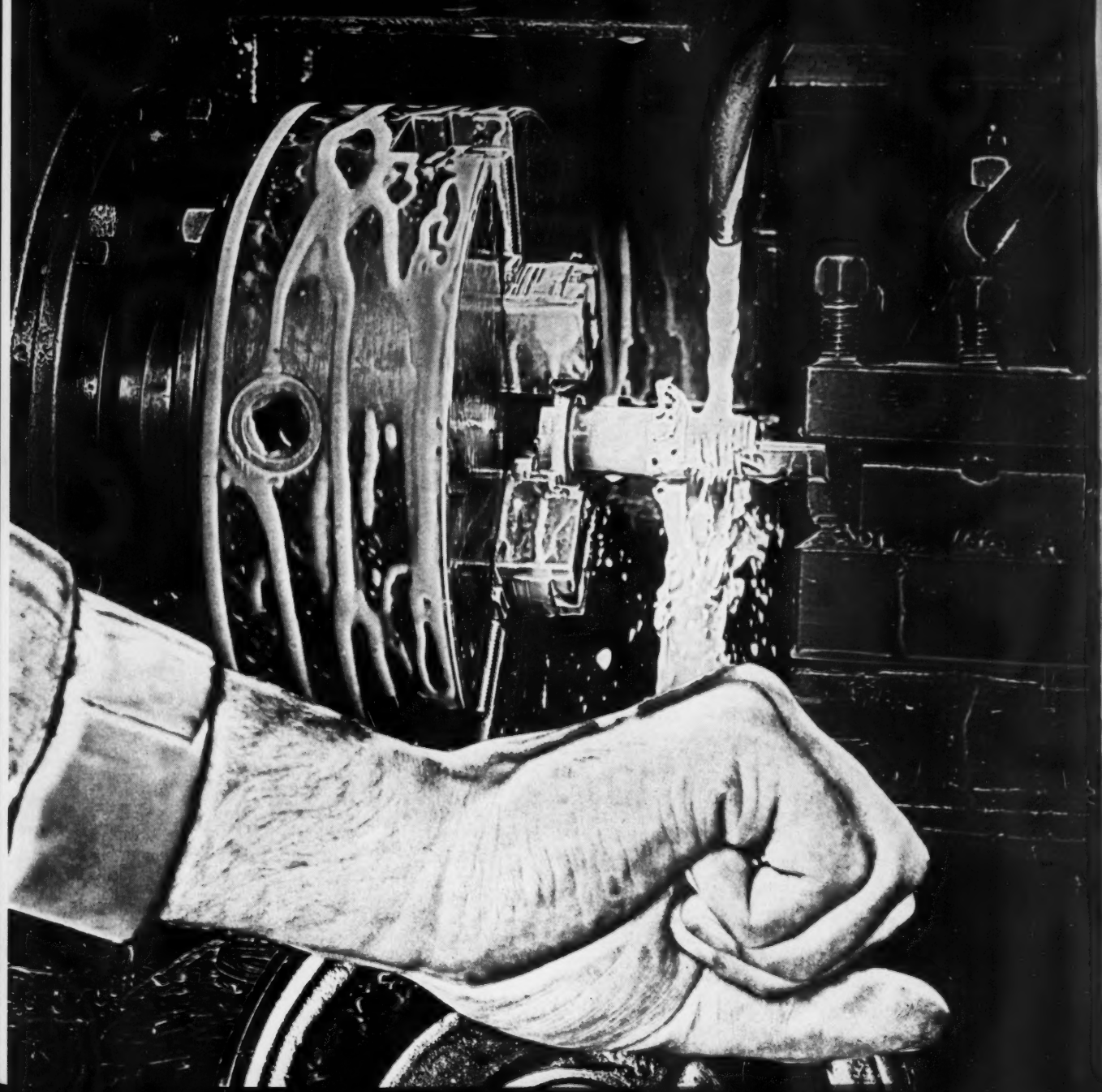
This will in effect be a 40 ft × 8 ft laboratory with thick concrete walls and zinc bromide windows in which everything is carried out by means of either automatic machines or remotely controlled " master-slave " manipulators. It will be divided into two parts. In the first the stringers will be dismantled into their individual fuel elements and structural components. In the second part the fuel elements are examined, including the measurement of outside dimensions by means of mechanized gauges and radiographic inspection to show up any gross changes in the fuel inside the cam. Finally, equipment will be installed which will sort out fuel elements with defective cans which have remained sealed. This is a vital task since signals on the reactor burst fuel element detection gear only indicate the presence of one defective element among the 432 (in the case of beryllium canned fuel) or 168 (stainless steel canned fuel) elements in a stringer.

After this preliminary work the fuel elements, about 1,000 per week, will be taken to the metallurgical examination laboratory being built in one of the old Windscale Pile blower houses. This laboratory, which will be used for investigations on all types of fuel elements, will be equipped to carry out the most searching of investigations. Measurements will be made to ascertain the distribution of fission gases in irradiated elements, and studies will be made of how much of the gas has been retained in atomic form in the uranium oxide in which it was produced and how much has escaped to be retained in the can as a gas. In another part of the line sections through the UO_2 fuel will be cut and polished for microscopal examination. An electron as well as optical microscopes will be used.

Other important information will be derived from mechanical strength tests on fuel and can, from density measurements and from samples heated to temperatures higher than those obtained in the reactor.

The examination lines when completed will consist of 12 separate caves each with 4 ft 6 in. thick walls containing zinc bromide windows. Special handling equipment has been designed to enable operations to be carried out more quickly and efficiently than possible with the conventional " master slave " manipulators.

Greater safety for hands



With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

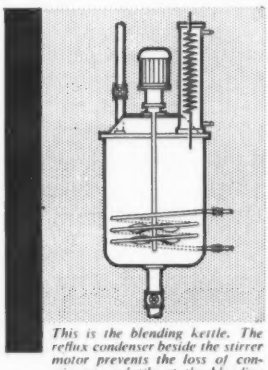
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organization have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication

INSTITUTION OF NUCLEAR ENGINEERS

The Articles of Association

General

1. In these presents the words standing in the first column of the Table next hereinafter contained shall bear the meaning set opposite to them respectively in the second column thereof, if not inconsistent with the subject or context—

WORDS	MEANINGS
The Act	The Companies Act, 1948.
These presents ..	These Articles of Association, and the regulations of the Institution from time to time in force.
The Association ..	The above-named Institution.
The Council ..	The Council of Management for the time being of the Institution.
The Office	The registered office of the Institution.
The Seal	The common seal of the Institution.
The United Kingdom	Great Britain and Northern Ireland.
Month	Calendar month.
In writing	Written, printed or lithographed, or partly one and partly another, and other modes of representing or reproducing words in a visible form.

And words importing the singular number only shall include the plural number, and vice versa.

Words importing the masculine gender only shall include the feminine gender; and

Words importing persons shall include corporations.

Subject as aforesaid, any words or expressions defined in the Act or any statutory modification thereof in force at the date on which these presents become binding on the Institution shall, if not inconsistent with the subject or context, bear the same meanings in these presents.

2. The number of members with which the Institution proposes to be registered is not limited.

3. The provisions of section 110 of the Act shall be observed by the Institution and every member of the Institution shall either sign a written consent to become a member or sign the register of members on becoming a member.

4. The Institution is established for the purposes expressed in the Memorandum of Association*.

5. The subscribers to the Memorandum of Association and such other persons as the Council shall admit to membership in accordance with the provisions hereinafter contained shall be members of the Institution.

*The draft of the Memorandum was published in the June issue of NUCLEAR ENERGY. Amendments made to the draft will be published in the August issue.

General Meetings

6. The Institution shall hold a General Meeting in every calendar year as its Annual General Meeting at such time and place as may be determined by the Council, and shall specify the meeting as such in the notices calling it, provided that every Annual General Meeting except the first shall be held not more than fifteen months after the holding of the last preceding Annual General Meeting, and that so long as the Institution holds its first Annual General Meeting within eighteen months after its incorporation it need not hold it in the year of its incorporation or in the following year.

7. All General Meetings, other than Annual General Meetings, shall be called Extraordinary General Meetings.

8. The Council may whenever it thinks fit convene an Extraordinary General Meeting, and Extraordinary General Meetings shall also be convened on such requisition, or in default may be convened by such requisitionists, as provided by section 132 of the Act.

9. Twenty-one days' notice in writing at the least of every Annual General Meeting and of every meeting convened to pass a Special Resolution, and fourteen days' notice in writing at the least of every other General Meeting (exclusive in every case both of the day on which it is served or deemed to be served and of the day for which it is given), specifying the place, the day and the hour of meeting, and in the case of special business the general nature of that business, shall be given in manner hereinafter mentioned to such persons (including the Auditors) as are under these presents or under the Act entitled to receive such notices from the Institution; but with the consent of all the members having the right to attend and vote thereat, or of such proportion of them as is prescribed by the Act in the case of meetings other than Annual General Meetings, a meeting may be convened by such notice as those members may think fit.

10. The accidental omission to give notice of a meeting to, or the non-receipt of such notice by, any person entitled to receive notice thereof shall not invalidate any resolution passed, or proceeding had, at any meeting.

Proceedings at General Meetings

11. All business shall be deemed special that is transacted at an Extraordinary General Meeting, and all that is transacted at an Annual General Meeting shall also be deemed special, with the exception of the consideration of the income and expenditure account and balance sheet, and the reports of the Council and of the Auditors, the election of members of the Council and the officers thereof in the place of those retiring, and the appointment of, and the fixing of the remuneration of, the Auditor.

12. No business shall be transacted at any General Meeting unless a quorum is present when the meeting

proceeds to business. Save as herein otherwise provided fifteen members personally present shall be a quorum.

13. If within half an hour from the time appointed for the holding of a General Meeting a quorum is not present, the meeting, if convened on the requisition of members, shall be dissolved. In any other case it shall stand adjourned to the same day in the next week, at the same time and place, or at such other place as the Council may determine, and if at such adjourned meeting a quorum is not present within half an hour from the time appointed for holding the meeting the members present shall be a quorum.

14. The Chairman (if any) of the Council shall preside as Chairman at every General Meeting, but if there be no such Chairman, or if at any meeting he shall not be present within fifteen minutes after the time appointed for holding the same, or shall be unwilling to preside, the members present shall choose some member of the Council, or if no such member be present, or if all the members of the Council present decline to take the chair, they shall choose some member of the Institution who shall be present to preside.

15. The Chairman may, with the consent of any meeting at which a quorum is present (and shall if so directed by the meeting) adjourn the meeting from time to time, and from place to place, but no business shall be transacted at any adjourned meeting other than business which might have been transacted at the meeting from which the adjournment took place. Whenever a meeting is adjourned for thirty days or more, notice of the adjourned meeting shall be given in the same manner as of an original meeting. Save as aforesaid, the members shall not be entitled to any notice of an adjournment, or of the business to be transacted at an adjourned meeting.

16. At any General Meeting a resolution put to the vote of the meeting shall be decided on a show of hands, unless a poll is, before or upon the declaration of the result of the show of hands, demanded by the Chairman or by at least three members present in person, and unless a poll be so demanded a declaration by the Chairman of the meeting that a resolution has been carried, or carried unanimously or by a particular majority, or lost, or not carried by a particular majority, and an entry to that effect in the minute book of the Institution shall be conclusive evidence of the fact without proof of the number or proportion of the votes recorded in favour of or against that resolution. The demand for a poll may be withdrawn.

17. Subject to the provisions of Article 18, if a poll be demanded in manner aforesaid, it shall be taken at such time and place, and in such manner, as the Chairman of the meeting shall direct, and the result of the poll shall be deemed to be the resolution of the meeting at which the poll was demanded.

18. No poll shall be demanded on the election of a Chairman of a meeting, or on any question of adjournment.

19. In the case of an equality of votes, whether on a show of hands or on a poll, the Chairman of the meeting shall be entitled to a second or casting vote.

20. The demand of a poll shall not prevent the continuance of a meeting for the transaction of any business other than the question on which a poll has been demanded.

Votes of Members

21. Subject as hereinafter provided, only full and associate members shall have one vote.

22. Save as herein expressly provided, no member other than a member duly registered, who shall have paid every subscription and other sum (if any) which shall be due and payable to the Institution in respect of his membership, shall be entitled to vote on any question at any General Meeting.

23. Votes may be given on a poll at Annual General and all other General Meetings either personally or by post as hereinafter provided. Notices in accordance with Clause 9 hereof shall be sent to each member with a copy of each resolution to be submitted to the members at such meetings as aforesaid. The copy resolution shall contain a space for each member who does not desire to be present at such meetings, to signify whether he wishes to vote for or against each resolution. If this notice is returned to the Secretary by prepaid post so that it reaches the Secretary at least three clear days before such meetings exclusive of the day of such meetings, such

New Institution Members

K. Allsopp, A
Oadby, Leicester.

Donald Baker, A
Barrowash, Derbys.

John Biggerstaff, A
Thurso, Scotland.

Jack Briggs, A
Belper, Derbys.

J. R. Burton, JM
Chandlers Ford, Sussex.

M. F. R. Burton, A
Sutton Coldfield, War.

J. P. Carter, A
Seascale, Cumberland.

T. S. Crawford, M
Didcot, Berks.

K. W. Dickinson, A
Basingstoke, Hants.

F. S. Dickinson, A
Basingstoke, Hants.

R. J. Doble, M
Barrow-in-Furness, Lancs.

P. J. Fretter, A
Wheathampstead, Herts.

P. L. Gadbury, M
Cholehurst, Kent.

W. A. Garratt, A
Duffield, Derby.

K. C. Graham, A
Macclesfield, Ches.

J. R. Greenland, A
Basingstoke, Hants.

D. M. Hamilton, M
Motherwell, Lanarks.

C. D. C. Hardy, JM
Radlett, Herts.

M. J. Hewitt, A
Basingstoke, Hants.

L. Hutchinson, A
Abingdon, Berks.

Norval Jackson, A
Dursley, Glos.

M. J. Jennings, A
Iver, Bucks.

W. J. Jordan, A
Wilmslow, Ches.

S. A. Lacey, M
Hertfordshire.

G. B. Lovatt, JM
Bromwich, Nr. Birmingham

F. A. R. Mayo, A
Berkeley, Glos.

G. A. Maundrell, A
Bexleyheath, Kent.

Lal Hiranand Mirchandani, M
London.

J. Morgan, A
Leeds, Yorks.

G. Moses, A
Basingstoke, Hants.

W. T. Nunn, M
Bletchley, Bucks.

J. R. Parker, A
Bristol.

J. S. H. Read, A
Derby.

A. J. Sayers, M
Knutsford, Ches.

J. J. Spyra, M
Manchester.

F. W. Stokes, M
Chalfont St. Giles, Bucks.

G. Stroud, A
Didcot, Berks.

R. A. Summers, A
Bilston, Staffs.

F. M. Telling, A
Didcot, Berks.

K. G. Williams, A
Ashton Vale, Bristol.

G. W. Williams, A
Mickleover, Derbys.

indication shall count as a vote for or against the resolution. Those notices which do not reach the Secretary at least three clear days before the meeting as aforesaid, shall be disqualified.

Council of Management

24. Until otherwise determined by a General Meeting, the number of the members of the Council shall not be less than four nor more than twenty-two.

25. The first members of the Council shall be the subscribers to the Memorandum of Association.

26. The Council may from time to time and at any time appoint any member of the Institution as a member of the Council, either to fill a casual vacancy or by way of addition to the Council, provided that the prescribed maximum be not thereby exceeded. Any member so appointed shall retain his office only until the next Annual General Meeting, but he shall then be eligible for re-election.

27. No person who is not a member of the Institution shall in any circumstances be eligible to hold office as a member of the Council.

28. No person shall be required to vacate his office as a member of the Council by reason of his attaining or having attained the age of seventy years or more.

Powers of the Council

29. The business of the Institution shall be managed by the Council who may pay all such expenses of, and preliminary and incidental to, the promotion, formation, establishment and registration of the Institution as they think fit, and may exercise all such powers of the Institution, and do on behalf of the Institution all such acts as may be exercised and done by the Institution, and as are not by statute or by these presents required to be exercised or done by the Institution in General Meeting, subject nevertheless to any regulations of these presents, to the provisions of the statutes for the time being in force and affecting the Institution, and to such regulations, being not inconsistent with the aforesaid regulations or provisions, as may be prescribed by the Institution in General Meeting, but no regulation made by the Institution in General Meeting shall invalidate any prior act of the Council which would have been valid if such regulation had not been made.

30. The members for the time being of the Council may act notwithstanding any vacancy in their body; provided always that in case the members of the Council shall at any time be or be reduced in number to less than the minimum number prescribed by or in accordance with these presents, it shall be lawful for them to act as the Council for the purpose of admitting persons to membership of the Institution, filling up vacancies in their body, or of summoning a General Meeting, but not for any other purpose.

Secretary

31. The Secretary shall be appointed by the Council for such time, at such remuneration and upon such conditions as they may think fit, and any Secretary so appointed may be removed by them. The provisions of sections 177 and 179 of the Act shall apply and be observed. The Council may from time to time by resolution appoint an assistant or deputy Secretary, and any person so appointed may act in place of the Secretary if there be no Secretary or no Secretary capable of acting.

The Seal

32. The seal of the Institution shall not be affixed to any instrument except by the authority of a resolution of the Council, and in the presence of at least two members of the Council and of the Secretary, and the said members and Secretary shall sign every instrument to which the seal shall be so affixed in their presence, and in favour of any purchaser or person *bona fide* dealing with the Institution such signatures shall be conclusive evidence of the fact that the seal has been properly affixed.

Disqualification of Council Members

33. The office of a member of the Council shall be vacated:—

(*a*) If a receiving order is made against him or he makes any arrangement or composition with his creditors.

(*b*) If he becomes of unsound mind.

(*c*) If he ceases to be a member of the Institution.

(*d*) If by notice in writing to the Institution he resigns his office.

(*e*) If he ceases to hold office by reason of any order made under section 188 of the Act.

(*f*) If he is removed from office by a resolution duly passed pursuant to section 184 of the Act.

Rotation of Members of the Council

34. The Council shall be elected for three years. At the first Annual General Meeting and at the Annual General Meeting to be held in every subsequent year, one-third of the members of the Council for the time being, or if their number is not a multiple of three then the number nearest to one-third, shall retire from office.

35. The members of the Council to retire shall be those who have been longest in office since their last election or appointment. As between members of equal seniority, the members to retire shall in the absence of agreement be selected from among them by lot. The length of time a member has been in office shall be computed from his last election or appointment. A retiring member of the Council shall be eligible for re-election.

36. The Institution may, at the meeting at which a member of the Council retires in manner aforesaid, fill up the vacated office by electing a person thereto, and in default the retiring member shall, if offering himself for re-election, be deemed to have been re-elected, unless at such meeting it is expressly resolved not to fill such vacated office, or unless a resolution for the re-election of such member shall have been put to the meeting and lost.

37. No person not being a member of the Council retiring at the meeting shall, unless recommended by the Council for election, be eligible for election to membership of the Council at any General Meeting, unless within the prescribed time before the day appointed for the meeting there shall have been given to the Secretary notice in writing, by three members duly qualified to be

Council Members guests at SAVOY HOTEL RECEPTION

Princes Press Ltd., proprietors of NUCLEAR ENERGY, **recently held a reception at the Savoy Hotel, London, to celebrate the 21st year of publication of their journal** THE CONSULTING ENGINEER. **Over 200 guests attended and among them were members of the Institution of Nuclear Engineers and many representatives of organizations closely concerned with nuclear energy matters. In top photograph Sir John M. Duncanson, president of the Institution, talks with Mr. Stanley White (*left*) of Associated Electrical Industries Ltd., and Mr. Martin Whitehouse, secretary of the Nuclear Energy Trade Associations' Conference. In the photograph on the right, host Mr. J. B. Pinkerton, who is secretary of the Institution, has a word with Council members Mr. A. E. Merrin (*left*) and Mr. H. F. Jones**

present and vote at the meeting for which such notice is given, of their intention to propose such person for election, and also notice in writing, signed by the person to be proposed, of his willingness to be elected. The prescribed time above mentioned shall be such that, between the date when the notice is served, or deemed to be served, and the day appointed for the meeting there shall be not less than four nor more than twenty-eight intervening days.

38. The Institution may from time to time in General Meeting increase or reduce the number of members of the Council, and determine in what rotation such increased or reduced number shall go out of office, and may make the appointments necessary for effecting any such increase.

39. In addition and without prejudice to the provisions of section 184 of the Act, the Institution may by Extraordinary Resolution remove any member of the Council before the expiration of his period of office, and may by an Ordinary Resolution appoint another qualified member in his stead; but any person so appointed shall retain his office so long only as the member in whose place he is appointed would have held the same if he had not been removed.

Proceedings of the Council

40. The Council may meet together for the dispatch of business, adjourn and otherwise regulate their meetings as they think fit, and determine the quorum necessary for the transaction of business. Unless otherwise determined, three shall be a quorum. Questions arising at any meeting shall be decided by a majority of votes. In case of an equality of votes the Chairman shall have a second or casting vote.

41. A member of the Council may, and on the request of a member of the Council the Secretary shall, at any time, summon a meeting of the Council by notice served upon the several members of the Council. A member of the Council who is absent from the United Kingdom shall not be entitled to notice of a meeting.

42. The Council shall from time to time elect a Chairman who shall be entitled to preside at all meetings of the Council at which he shall be present, and may determine for what period he is to hold office, but if no such Chairman be elected, or if at any meeting the Chairman be not present within five minutes after the time appointed for holding the meeting and willing to preside, the members of the Council present shall choose one of their number to be Chairman of the meeting.

43. A meeting of the Council at which a quorum is present shall be competent to exercise all the authorities, powers and discretions by or under the regulations of the Institution for the time being vested in the Council generally.

44. The Council may delegate any of their powers to committees consisting of such member or members of the Council as they think fit, and any committee so formed shall, in the exercise of the powers so delegated, conform to any regulations imposed on it by the Council. The meetings and proceedings of any such committee shall be governed by the provisions of these presents for regulating the meetings and proceedings of the Council so far as applicable and so far as the same shall not be superseded by any regulations made by the Council.

45. All acts *bona fide* done by any meeting of the Council or of any committee of the Council or by any person acting as a member of the Council, shall, notwithstanding it be afterwards discovered that there was some defect in the appointment or continuance in office of any such member or person acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed or had duly continued in office and was qualified to be a member of the Council.

46. The Council shall cause proper minutes to be made of all appointments of officers made by the Council and of the proceedings of all meetings of the Institution and of the Council and of committees of the Council, and all business transacted at such meetings, and any such minutes of any meeting, if purporting to be signed by the Chairman of such meeting, or by the Chairman of the next succeeding meeting, shall be sufficient evidence without any further proof of the facts therein stated.

47. A resolution in writing signed by all the members for the time being of the Council or of any committee of the Council who are entitled to receive notice of a meeting of the Council or of such committee shall be as valid and effectual as if it had been passed at a meeting of the Council or of such committee duly convened and constituted.

Accounts

48. The Council shall cause proper books of account to be kept with respect to—

(*a*) all sums of money received and expended by the Institution and the matters in respect of which such receipts and expenditure take place;

(*b*) all sales and purchases of goods by the Institution; and

(*c*) the assets and liabilities of the Institution.

Proper books shall not be deemed to be kept if there are not kept such books of account as are necessary to give a true and fair view of the state of the affairs of the Institution and to explain its transactions.

49. The books of account shall be kept at the office, or subject to section 147 (3) of the Act, at such other place or places as the Council shall think fit, and shall always be open to the inspection of the members of the Council.

50. The Institution in General Meeting may from time to time impose reasonable restrictions as to the time and manner of the inspection by the members, other than members of the Council, of the accounts and books of the Institution, or any of them, and subject to such restrictions the accounts and books of the Institution shall be open to the inspection of such members at all reasonable times during business hours.

51. At the Annual General Meeting in every year the Council shall lay before the Institution a proper income and expenditure account for the period since the last preceding account (or in the case of the first account since the incorporation of the Institution) made up to a date not more than four months before such meeting, together with a proper balance sheet made up as at the same date. Every such balance sheet shall be accompanied by proper reports of the Council and the Auditors, and copies of such account, balance sheet and reports (all of which shall be framed in accordance with any statutory requirements for the time being in force) and of any other documents required by law to be annexed or attached thereto or to accompany the same shall not less than twenty-one clear days before the date of the meeting, subject nevertheless to the provisions of section 158 (1) (*c*) of the Act, be sent to the Auditors and to all other persons entitled to receive notices of General Meetings in the manner in which notices are hereinafter directed to be served. The Auditors' report shall be open to inspection and be read before the meeting as required by section 162 of the Act.

Audit

52. Once at least in every year the accounts of the Institution shall be examined and the correctness of the income and expenditure account and balance sheet ascertained by one or more properly qualified Auditor or Auditors.

53. Auditors shall be appointed and their duties regulated in accordance with sections 159 to 162 of the Act, the members of the Council being treated as the Directors mentioned in those sections.

Notices

54. A notice may be served by the Institution upon any member, either personally or by sending it through the post in a prepaid letter, addressed to such member at his registered address as appearing in the register of members.

55. Any member described in the register of members by an address not within the United Kingdom, who shall from time to time give the Institution an address within the United Kingdom at which notices may be served upon him, shall be entitled to have notices served upon him at such address, but, save as aforesaid and as provided by the Act, only those members who are described in the register of members by an address within the United Kingdom shall be entitled to receive notices from the Institution.

56. Any notice, if served by post, shall be deemed to have been served on the day following that on which the letter containing the same is put into the post, and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and put into the post office as a prepaid letter.

Dissolution

57. Clause 8 of the Memorandum of Association relating to the winding up and dissolution of the Institution shall have effect as if the provisions thereof were repeated in these Articles.

Fluorine Products and N-Energy

II – The Properties and Applications of Fluorine

(*Continued from page 274*)

IN the manufacture of fluorine, special care must be taken in the selection of materials for the construction of the plant. The most suitable are summarized in Table I, in which the letters G and L signify suitable for handling fluorine in the gaseous and liquid condition respectively. All items of plant must be thoroughly cleaned with carbon tetrachloride or trichlorethylene, purged with nitrogen, and then slowly passivated by bleeding into the plant a current of fluorine or chlorine trifluoride. Where possible, socket weld fittings should be used. Threaded joints or tubes can be used, with backwelding. Valves should have seatings with dissimilar metals in contact, with packingless stem sealing, or if packing is used, then PTFE should be used in the stuffing box.

Bourdon gauges, all-welded in steel or Monel metal, are used. For the metering of flow, Pyrex rotameters with aluminium or stainless steel balls can be used, but there must be frequent recalibrations with nitrogen in order to counteract the inaccuracies due to slow etching. Gaskets of PTFE are required for rotameters.

Although fluorine is so highly reactive, it can be handled without undue hazard if proper precautions are taken. Remotely-controlled valves should be employed with the pressurized gas, and for high pressures, double valves are recommended. Neoprene gloves, coats and boots should be worn, and safety glasses should also be used. Vibration of tanks and ducts is to be avoided, since this may dislodge the resistant and protective films and accelerate further corrosion.

Disposal can be Problem

In operations where fluorine may not be completely used up, the question of disposal may arise, and the methods for this are very limited. The gas may not be discharged into the atmosphere, since it is very destructive to plant and animal life. On the small scale, fluorine may be allowed to react with common salt, with which it forms sodium fluoride and chlorine, the latter then being absorbed in soda-lime. Provided contact times of not less than one minute can be arranged, fluorine gas may be conveniently absorbed in caustic soda solution of 5 to 10 per cent. concentration. The gas should be brought into contact with this solution in spray- or packed-towers.

Disposal of fluorine by water scrubbing is not always satisfactory, and explosions have sometimes resulted. For undiluted fluorine, and for fluorine diluted with air, destruction by means of superheated steam has been recommended. The reaction at elevated temperatures is strongly exothermic, but the reaction may be controlled by cooling of the walls of the reactor. With fluorine above 50 molar per cent., a 500°F. inlet gas preheat induces immediate reaction with a 2-5-fold excess of steam. More steam than this may result in a damping of the reaction. With more dilute fluorine, a minimum preheat of 750°F. is required. The conditions at the nozzles at which the fluorine is burned in the steam are severe, and Monel metal appears to be the best material for the construction of the fluorine preheater, reactor nozzle, reactor chamber, and spray disposal tower.

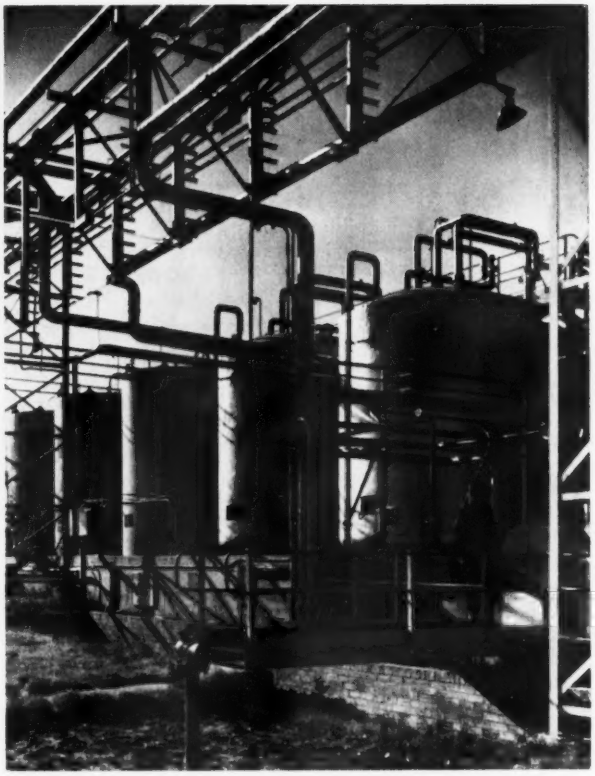
Only Convenient Way

Perhaps the most obvious application of fluorine to the development of nuclear energy was in the conversion of uranium into its hexafluoride, already mentioned in the section on hydrogen fluoride. Fluorine tends to bring out the maximum valency of any element, and the highest halogen compounds are likely to be the most volatile. For this reason, when it became necessary to find a stable, volatile uranium compound for the vapour diffusion process for separating uranium isotopes, the hexafluoride seemed the obvious choice. In fact, UF_6 is the only suitable compound of uranium which could be used.

It was also a matter of luck that fluorine happened to be an element of low atomic weight. The diffusion process relies for its success on differences in the molecular weights

Table I—Suitability of different materials for fabrication of various plant components. G—Fluorine in gaseous state, L in liquid state.

	Pipes and fittings	Storage tanks	Valve Parts					Gaskets
			Body	Seat	Plug	Packing	Bellows	
Aluminium	G L	G L		G L				G L
Brass	G		G	G				
Bronze			G L					
Copper	G L			G L				G L
Lead								G
Mild steel	G	G						
Monel	G L	L	L		G L		G L	
Nickel	G							
PTFE						G L		G
Stainless steel	G L	G L	G L		G L		G L	
Tin								G



Probably the best known use of fluorine in the nuclear energy field is the conversion of uranium to its hexafluoride by means of hydrogen fluoride. Uranium hexafluoride is the only suitable compound of uranium which can be used for the gaseous diffusion method of isotope separation, a process necessary for the production of enriched uranium fuel. The illustrations show (*above*) the plant at Springfields in which uranium tetrafluoride is further fluorinated to form the hexafluoride compound which is the feed material for the gaseous diffusion plant at Capenhurst; and (*right*) hydrogen fluoride storage tanks at Springfields

of the two molecular species involved. Thus, if we call UX the molecule which is to undergo diffusion, then the two species concerned are respectively $U^{235}X$ and $U^{238}X$. In order that there should be a maximum difference between the molecular weights of these, the weight of the fraction X must be as small as possible, and this is the case when the atom contained in this radical, namely fluorine, has as small an atomic weight as possible. However, UF_6, although comparatively easily prepared, is very dangerous, corrosive and extremely sensitive to traces of moisture.

A Challenge

The manufacture and handling of uranium hexafluoride was, therefore a real challenge to chemical engineers who had to devise plant for the diffusion process and the ancillary operations. Not only was fluorine the key element for the manufacture of a volatile uranium compound, then, but fluorinated hydrocarbons played a very important role in providing coatings, linings, valves, pumps, ducting, and even lubricants to withstand the highly corrosive compounds handled. Although it would be an exaggeration to say that without fluorine nuclear energy, whether as bomb or as reactors, would have been impossible, it surely would be correct to guess that these would have been delayed for at least 10 years but for the discovery of fluorine by Moissan.

Halogen Halides

Fluorine has also been applied to atomic energy in other interesting ways. One of these has involved the use of compounds of this halogen with other members of the same group of elements. By direct reaction between fluorine and chlorine and bromine, respectively, the compounds chlorine trifluoride ClF_3 and bromine trifluoride BrF_3 may be formed. The first of these is a colourless gas, of b.p. 12.1°C, and f.p. −82.6°C., while the other is a liquid of b.p. 127° and f.p. 8.8°C. Both are extremely reactive, perhaps even more so than fluorine itself. The bromine compound will attack even quartz at 30°C., while chlorine trifluoride attacks both glass and quartz at even lower temperatures. Further, the latter compound has such tremendous reactivity towards water that should water be introduced into a vessel containing a little of the gas, the reaction occurs with such violence that the water is ejected.

Highly reactive though these two fluorine compounds are, they have found application in a method for the reprocessing of spent fuel elements. When they are allowed to react, under controlled conditions, with the fuel elements, they convert the latter into a mixture of fluorides. When the latter is heated, the fission products krypton and xenon are first driven off, and then the uranium in the form of its hexafluoride UF_6. Further heating produces a fractional distillation of the fluorides of caesium, strontium, barium, yttrium, lanthanum, cerium, praseodymium, zirconium, arsenic, tellurium, plutonium, iodine, molybdenum, niobium, etc. This process constituted just one concept of the non-aqueous processes which have been applied to the regaining of uranium and plutonium from spent fuel from reactors.

Liquid Fuel Reactor

Brief mention may be made finally of a few more fluorine compounds encountered in atomic energy fields. Uranyl fluoride, UO_2F_2, is a water-soluble salt which has been considered

(*Continued on page 320*)

Atomic Weight of Silver
REVALUATION HAS BEEN MADE

A NEW value of the atomic weight of silver—a key element in determining atomic weights of other elements—has been obtained by the National Bureau of Standards with the co-operation of the Atomic Energy Commission. The new value results directly from a highly accurate determination of the absolute isotopic abundance ratio[1] of silver using the techniques of mass spectrometry. This determination was carried out by W. R. Shields and Dr. V. H. Dibeler of the Bureau's mass spectrometry laboratory and Dr. D. N. Craig of the electrochemistry laboratory.

The work on the atomic weight of silver was part of a broad programme the purpose of which is to obtain more accurate values of fundamental constants in order to meet the continuing demands of science and industry for more precise measurements. Besides its use in establishing the atomic weights of other elements, the atomic weight of silver plays an important part in the assignment of values to other fundamental constants, such as Avogadro's number, the faraday, and the gas constant. Redetermination of the faraday[2] was the principal reason this research on silver was initiated.

Natural silver consists of two isotopes of approximately equal abundance: Ag107 and Ag109. Although the mass of each isotope is known in relative atomic units, until recently the isotopic abundance ratio (Ag107/Ag109) had not been measured accurately—that is, by using synthetic mixtures of silver isotopes as calibration samples. The abundance ratio of the two silver isotopes had been determined at other laboratories, but substantial differences had been reported in the values obtained.

Bias Determined

In general, the mass spectrometer will indicate slightly higher concentrations of one isotope than another, even though both isotopes may be present to the same extent. For this reason, it was necessary first of all to determine the instrumental bias. This bias was measured by calibrating the instrument with pure silver samples especially prepared to contain known abundance ratios of the isotopes. A small but accurately measurable discrimination of approximately 0.5 per cent. in favour of Ag107 was found.

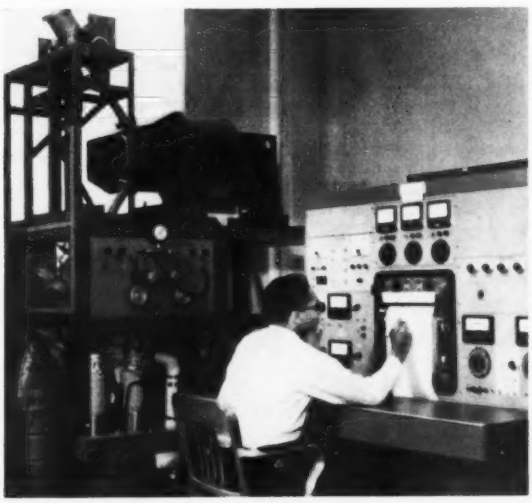
Once the mass spectrometer bias had been measured, the absolute isotopic abundance ratio of naturally occurring silver could be accurately determined. This ratio was measured for reference silver nitrate and for native silver from various parts of the world. The variation among these samples was found to be insignificant, with one exception. From this isotopic ratio of the reference silver, corrected for the observed bias, the absolute atomic weight of silver was computed as 107.8731 ± 0.0016 on the chemical scale[3]. This figure differs significantly from the internationally accepted chemical value of 107.880.

The mass spectrometer used for these experiments is a single-focusing, surface-emission instrument having a 12 in. radius-of-curvature and 60° deflection. Rhenium is used in the triple-filament source[4] for all the sample filaments as well as for the source of ions. As in similar cases, this metal is used as a compromise of work function and high melting point to obtain the best yield of silver ions.

Five Blends Prepared

Separated silver isotopes were obtained from AEC's Oak Ridge National Laboratory for use as calibration samples. Five synthetic blends of silver were prepared with isotope ratios near that of naturally occurring silver. Although the total impurity content of other elements detectable in the original isotopes by spectrochemical analysis was less than 0.01 per cent., the metal used in two of these mixtures was further purified by electro-deposition. No difference was noted between results with the more highly purified samples and the others. Weighed portions of each isotope were dissolved together in nitric acid to form a homogeneous mixture and then evaporated to dryness. Extreme care was taken to prevent contamination and chemical discrimination.

After the 107/109 ratio of each synthetic mixture had been calculated from the known weights of Ag107 and Ag109, the mixtures were analyzed in the mass spectrometer. This is done by dissolving silver in nitric acid solution and depositing the resulting silver nitrate on the sample filament of the spectrometer. The deposited sample was then reconverted



Determining the absolute isotopic abundance ratio of silver by mass spectrometric analysis at the U.S. National Bureau of Standards

into metallic silver by electrically heating in a hydrogen atmosphere.

In each case, the spectrometer consistently gave a slightly higher ratio than the calculated value, indicating that the spectrometer discriminates in favour of the Ag107 isotope. The discrepancy is of the order of magnitude expected for thermal separation of the isotopes based on the square root of the ratio of the isotopic masses.

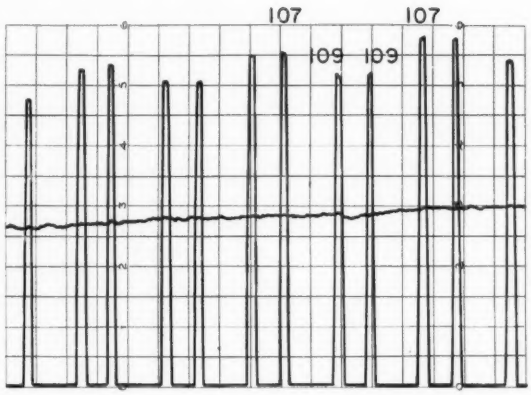
Seven Silvers Tested

To determine whether naturally occurring silver from widely scattered localities have identical isotopic compositions—and thus the same atomic weight—samples of natural silver were obtained from Arizona, Michigan, Montana, Canada, Honduras, Mexico, and Norway. In preparation for the measurements, these silvers were converted into silver nitrate solution. The isotopic abundances of the silver from these samples were measured in the mass spectrometer and then compared with the value obtained for a commercial silver nitrate sample. This material, adopted as a reference sample for the experiment, was used as a control.

In general, the isotopic compositions of all the silvers except the one from Canada were indistinguishable from that of the reference sample. Because the abundance of the Canadian silver was slightly, but significantly different, additional samples from the same region are now being studied.

Finding the Ratio

The Ag107/Ag109 ratio, 1.07547 ± 0.0013, is obtained by correcting the ratio of the reference silver nitrate for the measured degree of instrumental bias. This corrected abundance ratio multiplied by accurate values of the nuclidic masses—which were measured in a mass spectrometer by Dr. A. O. Nier and his colleagues at the University of Minnesota—results in an atomic weight for silver on the physical scale of 107.9028 ± 0.0011. If, in conformity with the practice of the Commission on Atomic Weights, the factor 1.000275 is used to convert to the chemical scale, 107.8731 ± 0.0016 is obtained for the atomic weight of silver. The increase in the uncertainty results from an additional variance in the conversion factor.



Typical mass spectrometric data for silver, showing the continual recording of Ag^{107} and Ag^{109}. The abscissa corresponds to the mass of silver and the ordinant, to silver's abundance. The continuous nearly horizontal line indicates the total ion current of both isotopes

The uncertainty in the present physical determination of the atomic weight of silver is estimated from the degree of variance and limit of error of bias for several thousand sample determinations.

References

[1] SHIELDS, W. R., CRAIG, D. N., and DIBELER, V. H., "Absolute isotopic abundance ratio and the atomic weight of silver." Submitted for Publication.

[2] "Improved value for the faraday by new experimental process." *Tech. News Bul.* **44**, **34** (1960) STR 2447.

[3] The chemical scale is based on the value of 16 as the relative mass for the natural isotopic abundance of oxygen, whereas the physical scale is based on the value of exactly 16 for the relative mass of just one isotope, O^{16}.

[4] INGRAM, M. G., and CHUPKA, W. A., *Rev. Sci. Instruments* 24, 518 (1953).

FLUORINE and N-ENERGY

(*Continued from page 318*)

suitable for the incorporation of enriched uranium fuel into aqueous solutions for homogeneous reactors. It has the great advantage of having a very low tendency to absorb neutrons in a parasitic fashion but it does have also the disadvantage of undergoing considerable hydrolysis at elevated temperatures, unless considerable amounts of free hydrofluoric acid are present, a condition which leads to great corrosion. Thorium fluoride is involved in one method for the winning of thorium from monazite. In this process the monazite is decomposed with caustic soda, which gives water soluble sodium phosphate and an insoluble residue of hydroxides; the latter is decomposed with hydrochloric acid, giving soluble chlorides. The hydroxides are re-formed by caustic soda, then converted into nitrates, of which the uranium and thorium salts can be extracted by organic solvents. The thorium is then converted into oxalate, leaving the uranium in the organic layer, while the oxalate is ignited to oxide, and then heated in hydrogen fluoride to give thorium fluoride ThF_4. This compound may then, in the same way as uranium fluoride, be reduced to the metal by heating with metallic calcium.

For Detecting Neutrons

Lithium can be used as a neutron detector, since it undergoes a reaction of the (n:alpha) type with neutrons, the reaction being expressed by the equation: ${}^{6}_{3}Li + {}^{1}_{0}n = {}^{4}_{2}He + {}^{3}_{1}T$. The helion and triton particles are ejected with very high yield and high kinetic energy, and it is the detection of these which indirectly amounts to a detection and measurement of the neutrons. The best salt of lithium for this purpose, by virtue of high sensitivity, and low tendency to capture neutrons parasitically, is the fluoride, LiF.

Sufficient evidence has been given here of the very great contribution made by fluorine and its compounds to the progress of nuclear energy. If it were possible for Moissan to return to life for a short spell, it is certain that he would be able to realize that he had not in fact wasted 10 years of his life on fluorine, but has contributed very considerably to nuclear progress for the benefit of mankind.

Pressure Suppression Containment for Nuclear Power Plants*

by C. C. Whelchel† and C. H. Robbins‡

Part II—Design Considerations of Systems

(*Continued from page 271*)

THE pressure-suppression system used as a general frame of reference for the following section is that shown in Fig. 1 (page 263).

Dry Well

The dry well should maintain its integrity following the unlikely occurrence of a break in the primary system. If the dry well were to break, the water pool could be bypassed, the enclosure could rupture, and any fission products released to the dry well might escape to the environs and be a health hazard. Threats to dry-well integrity are blast, dynamic force, missiles, and static pressure.

(1) *Blast.* If a rupture of the primary system were to occur suddenly, a shock wave would form in advance of the interface of the air and steam-water issuing from the break. The dry well should withstand the resulting blast. Simplified calculations were made, treating the shock wave as being plane rather than spherical. The results compared with other factors to be considered, showed that the blast pressure on the dry well wall would not be a controlling design condition. The analysis gave a blast pressure of 248 lb/sq.in. at the dry-well wall for an initial reactor pressure of 1,000 lb/sq.in. abs. and an initial pressure of 14.7 lb/sq.in. abs. for the air in the dry well.

(2) *Dynamic Force.* Dynamic force from a jet issuing from a break in the primary system is an important consideration in design of the dry well. The dynamic force of the jet on the wall can be calculated readily by assuming flow through the break to be equivalent to an orifice, and by assuming that the direction of the fluid after striking the wall is 90° from the initial direction. The dry-well wall under the circumstances should be able to withstand the momentum of the jet. Because of the directional character of the jet, its high velocity, and the short distance between dry-well wall and break, the jet would not be likely to expand very much by the time it struck the dry-well wall. Consequently, the force of the jet would be concentrated in an area not much bigger than the break in the primary system. With the assumptions listed, the total dynamic force would be directly proportional to the break area and to the initial reactor-vessel pressure. If the initial reactor pressure is 1,000 lb/sq.in. abs. and the break area is 0.785 sq.ft, the dynamic force on the dry-well wall is calculated to be 145,000 lb on the basis of the assumptions described.

(3) *Missiles.* The dry well must also be designed so it would not be breached by any missiles which could result from parts being torn loose and accelerated by a jet of steam-water. The reactor vessel itself should be braced so that it could not become a missile from the reaction force of a jet.

(4) *Static Pressure.* If a rupture were to occur in the primary system, static pressure would rise in the dry well, reach a maximum, and then drop off. A most important requirement of a dry well is that it be capable of withstanding the peak static pressure. The following factors affect peak static pressure, and the importance of each depends on the design conditions: Volume of the reactor vessel; Initial state of vessel contents such as pressure and amount of steam and water; Size and location of the break; Volume of the dry well; Vent flow area; and Vent depth of submergence.

When Vent Area Large

If the vent area was large enough, an increase in it would have a small effect on reducing the peak dry-well pressure. Under these circumstances, after a break, pressure would build up in the dry well, accelerating the water down out of the vents. Peak dry-well pressure would occur when the water has just been expelled and the pressure would drop rapidly as soon as the air and steam in the dry well could blow directly in to the water pool. The peak pressure would be determined by the time required to move the mass of water out of the vents. With these conditions, depth of submergence would be an important factor in determining peak static pressure in the dry well.

If the vent area was too small compared with the size of the break, the water pool would not be effective as a heat sink; peak pressure would have been reached before a significant amount of air and steam from the dry well could be forced through the vents in to the water. In this situation, the volume of the reactor vessel, initial state of the reactor-vessel contents, and the dry-well volume would be the most important factors in determining peak static pressure

If the vents were designed to utilize the water pool effectively (large vent area and small depth of submergence) the relative amounts of water and steam in the reactor would be unimportant. This is true because the peak static pressure in the dry well would be determined

*Paper presented at the 1959 Annual Meeting of the American Society of Mechanical Engineers.

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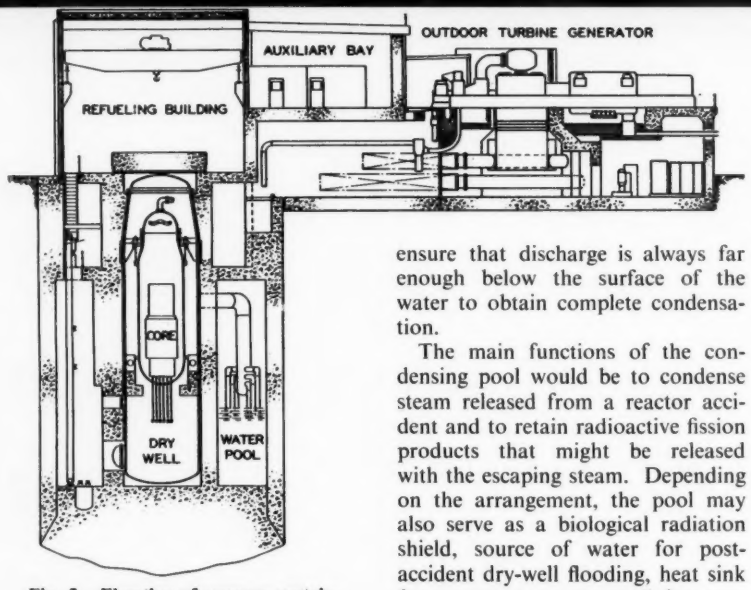


Fig. 5.—Elevation of pressure containment suppression containment system designed for Humboldt reactor unit No. 3

by the flow from the vessel in the first short period of time. This flow would be a small fraction of the total contents of the vessel.

The location of the break in the primary system of a boiling water reactor is also important in determining peak dry-well pressure for an effectively designed pressure-suppression containment system. Analysis shows that for a given break and an initial pressure of 1,000 lb/sq.in. abs. the energy release rate to the dry well is about five times as great for an all-liquid flow as for all-steam flow. Consequently, a break at a bottom connection to a boiling-water reactor vessel will create a higher peak dry-well pressure than will one at the top.

Simplicity the Key

The tests indicated steam can be condensed in the water pool very satisfactorily by discharging through simple straight pipes. Other steam injectors would probably operate satisfactorily also, but there is now no known advantage in using more elaborate equipment.

Within the range of the tests, no significant diameter effect was found. Tests included pipe diameters of 4, 6, 8, and 14 in., although the steam supply was inadequate to establish jet flow from the 14 in. diameter pipe.

The open end of the vents should be submerged sufficiently so that the jet momentum does not depress the water surface below the end of the pipe. Depth of submergence should be small to keep peak dry-well pressure low, but the submergence should be large enough to ensure that discharge is always far enough below the surface of the water to obtain complete condensation.

The main functions of the condensing pool would be to condense steam released from a reactor accident and to retain radioactive fission products that might be released with the escaping steam. Depending on the arrangement, the pool may also serve as a biological radiation shield, source of water for post-accident dry-well flooding, heat sink for emergency pressure-relief system, heat sink for emergency load-dump system, and storage for fuel.

The volume of pool water should be large enough to absorb the potential energy release from the reactor water with a maximum water temperature of about 120°-130°F. Tests indicated that pressure waves in the water during high steam-discharge rates may be large if the water temperature exceeds this value. With this limitation, the volume of water depends upon the total energy released, and the initial water temperature. It is important that the vent pipes and water pool be so arranged that good mixing will take place.

The primary function of the containment vessel over the water pool would be to retain radioactive isotopes that might be released. It is, in effect, a back-up on the water pool and dry well.

The pressure rise in the containment vessel would be created largely by the air purged from the dry well. With proper design, the design pressure for the enclosure may be only a few lb/sq.in. gauge. The magnitude of the pressure rise in the containment vessel is a function of system parameters, such as, ratio of containment volume to dry-well volume, ratio of initial and containment pressures, and ratio of initial dry well and containment temperatures. Vapour pressure of the water pool is not apt to be very significant if the water-pool temperature does not exceed 120°-130°F.

The results of the development programme are now being applied in further work aimed at designing a pressure-suppression containment scheme for Humboldt Bay Unit No. 3.

The reactor system including the primary vessel, dry well, and pressure-suppression pool, together with shielding and containment provisions, will be designed to minimize environmental hazards from leakage of fission products and radiation shine under the most severe credible accident conditions.

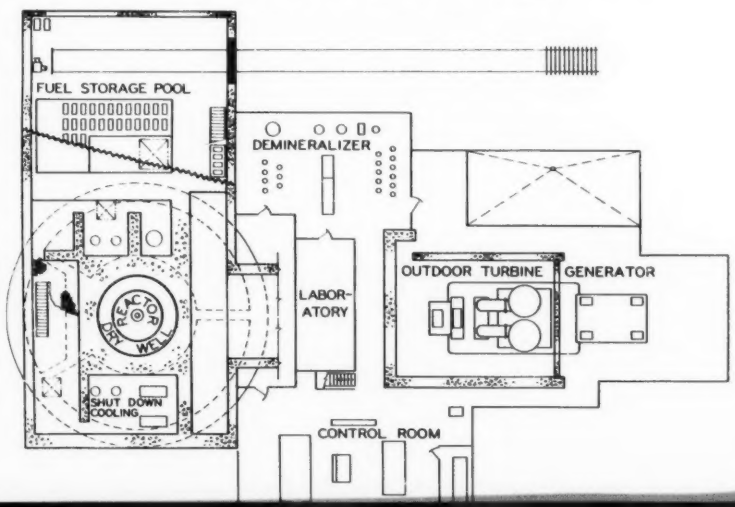
Different arrangements of the containment system are being studied. Sketches showing what a cross section and plan of the Humboldt unit may look like are given in Figs. 5 and 6.

Safer and Cheaper

Pressure suppression offers important safety advantages and shows considerable promise of being less expensive than dry-capsule-type containment for boiling-water or pressurized-water reactors.

The information in this article is a result of the efforts of many individuals. Special mention must be made of the important contributions of W. L. Fiock, E. Janssen, and A. G. Steamer of the General Electric Co., and J. O. Schuyler and D. B. Barton of Pacific Gas and Electric Co.

Fig. 6.—Plan of the system shown in Fig. 5



TRAINING reactors in British educational establishments have been a subject for both enthusiasm and criticism, but they are bound to come soon. Three British-built types are mentioned in a recent issue of *Technical Education*, and this may be taken as indicative that small reactors will soon be used by the more generously-endowed teaching institutions. The "Jason," based on the Argonne National Laboratory's "Argonaut," is a 10 kW unit built by the Hawker-Siddeley Nuclear Power Co., near Slough. Two of this type have already been sold—one to the UKAEA, for Winfrith, and the other to the Netherlands Government, for use at Petten. The 10 kW "Consort," manufactured by the General Electric-Simon-Carves group, costs only £50,000. The "Triga," originally designed by the General Atomics Division of General Dynamics Corporation, of U.S.A., is offered in this country by Vickers-Armstrongs at a price of £100,000. Of this type, with a 100 kW output, 15 have already been installed throughout the world. Competition between these three training reactors is likely to be quite keen.

* * *

The ever-growing bulk of scientific published work throughout the world has not only created tremendous difficulties in documentation and dissemination, but has highlighted more strongly than ever before the necessity of smoothing out language difficulties. English is undoubtedly most frequently used, but following this come German, Russian and Japanese, while Chinese is a close runner. The last three languages involve scripts, the learning of which is a burden over and above the acquisition of the necessary grammar and vocabulary. In an article published recently by the Chemical Society, H. M. Powell, of Oxford University, advises his readers to learn Japanese, and presents his theme very fascinatingly under the title "Japanese Chemical Writing—read it yourself." Whatever temptations I may have had to learn this Oriental language have finally been vanquished as a result of my reading in this article the complexities which the author so clearly pointed out.

In London, there are even courses in Chinese for scientists, and of course, Russian has been a "must" for some years. Are we not getting into the ridiculous position where in order to cope with the literature of science, we have to burden ourselves with the learning of several unnecessarily complex languages and scripts? Is there not something to be said for the resuscitation of Esperanto and for international agreement upon one language for the presentation of scientific papers and articles?

* * *

Dr. Glen Seaborg, the American nuclear scientist, has put in a plea for a sharing of the transuranic elements among the world's atomic research workers, through the medium of the IAEA. Since a single milligramme of californium costs millions of dollars, this is a very striking gesture. A long-term plan to produce more of

'NUCLEARIST' writes . . .

such elements in the U.S.A. is to be put into operation at once, and it may not be long before we hear of the discovery of element 103 and even heavier ones. About 100 g of curium and similar elements should become available around 1963, as a result of the irradiation of 12 kg of plutonium in the reactors at Savannah River.

* * *

Why is it that almost every occasion for joy must be followed by one for grief? The jubilation and pride of achievement which accompanied the starting-up of the world's greatest proton synchrotron at CERN, Geneva, has been followed by the shock of losing valued personnel. Professor Cornelis Jan Bakker, the director of the organization since 1955, was drowned when a small aircraft in which he was travelling made a forced landing near Long Island, U.S.A. It is fortunate that at least he was able to witness the functioning of the great accelerator on which he had devoted so much time and energies. On March 12, Mr. Albert Fehlmann, a mechanic in the proton synchrotron department, died after a long illness. Then, on April 17th came the death of the senior information officer, Jack Redpath McCabe, a Canadian by birth. He had devoted much energy to supplying a thirsty public with information on the work at CERN.

* * *

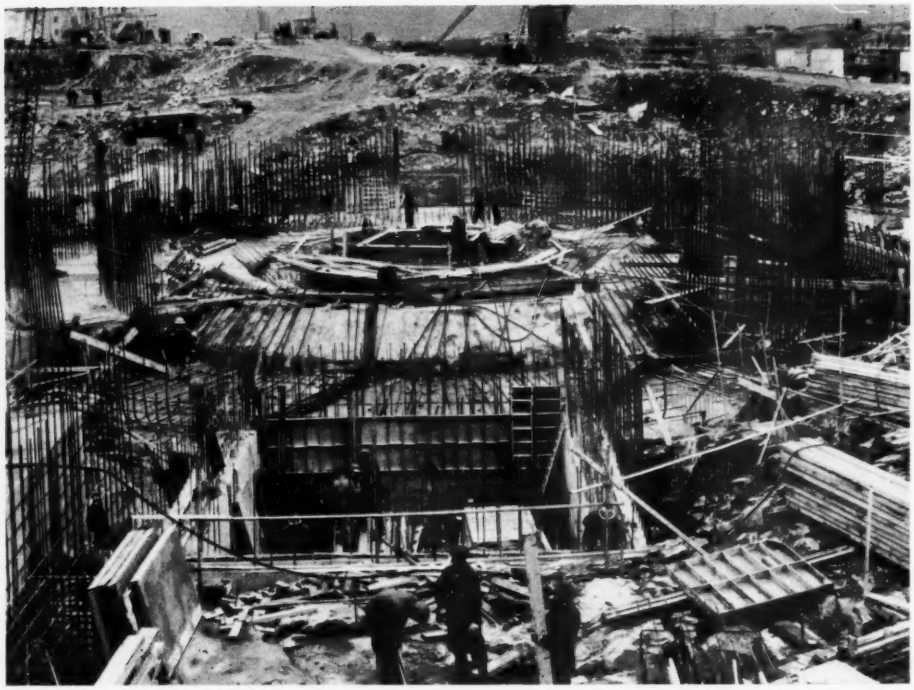
What is Europe's greatest research reactor? It would appear that the distinction is claimed by the critical assembly in the Swedish nuclear research centre at Studsvick, on the Baltic coast, south of Stockholm. Its maximum output is 30 MW, and it will be used for materials testing, and for development of the fuel elements to be used in the nuclear power station which is to be built underground near Stockholm. And underground, too, go Swedish ships, and canals, and a city where selected members of the community may perhaps survive the nuclear holocaust which many consider inevitable.

* * *

I was very interested to come across recently the details of a very ingenious and compact apparatus for the examination of the energy spectrum of nuclear radiations, such as gamma rays. Designed by Jean-Louis Van Eck, of the Université Libre de Bruxelles, Brussels, this apparatus uses a scintillation detector followed by photomultiplier, together with selector-, discriminator-, shaper- and retarding-circuits. Counting is by means of an electronic scaler and mechanical counter. The designer, although aware of the drawbacks of diodes and transistors, has been able to obtain great sensitivity and precision, thanks to a number of compensations in the design. Should any reader be interested and wish to know more about this apparatus, I should be happy to pass on a note of the source of my information.

* * *

The recent trip organized to Windscale to enable representatives of the press to see how work on the Advanced Gas Cooled Reactor was progressing provided for many pressmen a pleasant surprise. After all the knocks the Atomic Energy Authority has taken in the past few years it seemed they would never regain that wonderful spirit of the pre-Calder Hall days. Judging from the demeanour of the scientists and engineers working on the AGR, however, it is still there and nobody can but be infected by their buoyant confidence in the future they have plotted.



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U.K.'s Fifth N-Station

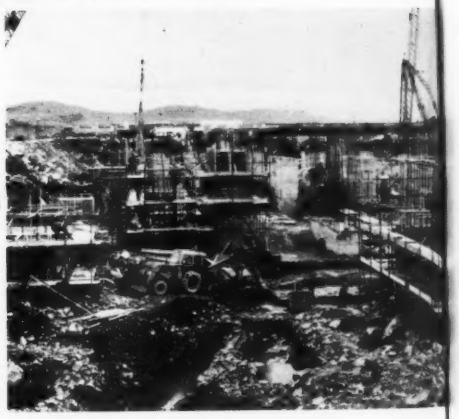
Report from Trawsfynydd

By J. N. Bishop, BSc, MIMechE,
Chief Construction Engineer, A.P.C. Ltd.

2

THE nuclear power station at Trawsfynydd differs from others being constructed in the British Isles in several respects. It is the only power station to be erected within a National Park and, as a result, considerable attention has had to be given to the architectural treatment of the station itself and the landscaping of the immediate surrounds. The circulating water system is unique in so far as natural cooling from the surface of a lake is used.

In order to ensure that there is a good circulation of water around the lake, a contract for the preliminary works was placed by the Electricity Generating Board some 12 months before the major work of the power station was started. This work consisted of constructing a wall linking several islands in the lake to ensure that the circulating water leaving the station passed around the periphery of the lake before being drawn back into the condensers.



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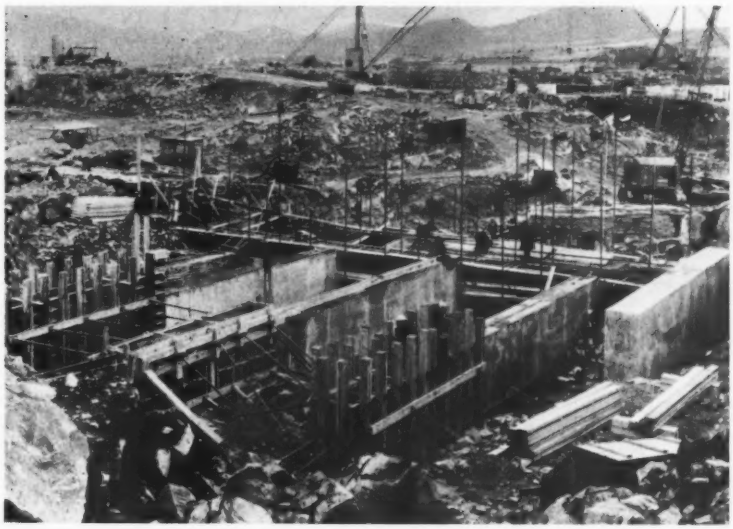
The power station is the highest steam station in the British Isles, as the lake at Trawsfynydd is some 650 ft above sea level. The lake itself forms the head waters for the hydro power station at Maentwrog. In order to transport heavy loads to the site it has been necessary to refurbish the Harbour at Portmadoc and equip it with cranes capable of unloading components of up to 150-tons weight.

The layout of the station itself and particularly that of the construction areas has been greatly governed by the topography of the site. Owing to the slope of the ground the major construction areas have been kept as small as possible.

Site Clearing Problematic

The problem of site cleaning was aggravated by the fact that the spaces between the boulders have been filled with rotting vegetable matter with tongues of liquid peat, penetrating up to 20 ft deep. The work of lifting the detritus was, as a result, a slow and laborious process, involving much excavation with relatively small machines and considerable blasting of the larger blocks in order to make them more easily handled. The eventual cleaning of the rock preparatory to laying the blinding concrete and the foundations had to be carried out by hand. The work on the construction areas and the provision of the facilities for the mechanical side is almost complete.

A large shop complete with a 60-ton overhead crane and automatic welding



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equipment has been erected and equipped for International Combustion Ltd. It is here that the steam raising units and the major part of the access duct will be fabricated. The steam raising units will be shipped to Portmadoc as circular strakes and welded into complete boilers within the shop, stress relieved in an oil fired furnace and then transported vertically down the site by the Goliath Crane and then placed in position on their plinths.

The first of the Babcock & Wilcox fabrication shops is in use and fabrication of the first pressure vessel is well in hand. The second shop will be erected as soon as the Goliath crane has been completed and the supporting guy wires removed. It is in these shops that the two pressure vessels will be manufactured in components as large as it is practicable to handle with the Goliath crane.

The Goliath crane is similar in all respects to that already erected and in use at Hinkley Point.

All Access Roads Complete

At the same time as the work on the construction areas is being carried out, work on the final buildings is being pushed ahead. The C.W. pipes to and from the lake to the turbine house are being laid as quickly as possible in order that the area can be backfilled and the final access roads brought into use. The work on the turbine house, which will be used to house four 145 MW sets, has reached the stage where all the concrete work in the sub-basement is complete.

Tour of the Site

Key to the Illustrations

1. Foundations for No. 1 reactor.
2. Erection of Goliath crane.
3. Turbine Hall from north.
4. Cooling water culverts.
5. Cooling pond area.

(*Bottom of page*) Panorama of site taken from batching plant

Work on the two reactor buildings is proceeding from opposite ends leaving a ramp access between the two buildings. The work on the first reactor has reached the stage where the blocks for the gas circulators are being cast and the steelwork for the shield cooling is being erected inside the biological shield of the first reactor. The north retaining wall of the second reactor and the blinding concrete is being placed.

The construction work on site has so far been largely concerned with civil engineering, though the installation of substations for power supplies and a certain amount of mechanical engineering has been completed. The original programme of the work is being closely followed, and the work of the civil contractor is proceeding to time.

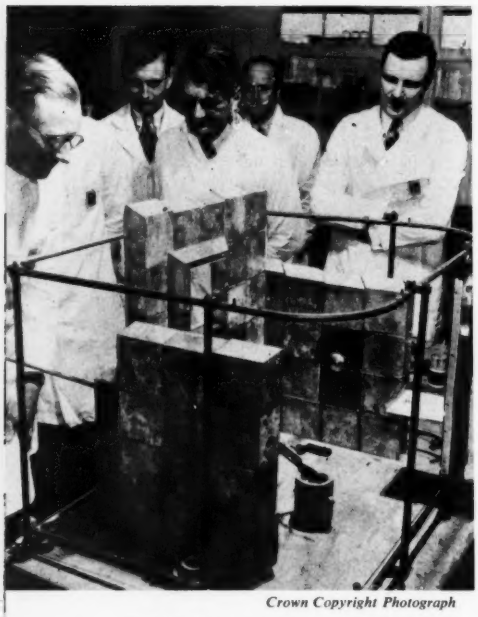
The site office administration buildings, canteen, stores blocks and maintenance workshops have all been erected and brought into use and the last few months has also seen the labour hostel on the site of an existing army camp at Bronaber, some five miles south of the power station.

The main contractors for the station are Atomic Power Constructions Ltd.

BACK TO SCHOOL

to learn about isotopes

University professors and heads of research, business executives and medical experts, engineers and chemists, lecturers and safety officers —all attend the UKAEA Isotopes School at Wantage, near Harwell. Why it is so popular is that it provides facilities for the teaching of techniques in the application of radioisotopes found nowhere else. This article describes the work of the school



Crown Copyright Photograph

Students learn how to use remote handling tools. Here they are being shown the method of inserting a capsule of radioactive material into a lead container

WHEN the Atomic Energy Authority's Isotope School was set up in 1951 it was thought that it would outlive its purpose within two years. To-day, nine years later, it is still in existence and its function as vital as ever. It has expanded, both in size and scope, and the demand for the training it provides in the safe and effective use of radioisotopes never flags. Indeed, there are invariably more applicants for a course than there are vacancies.

So far over 2,000 students from 58 different nations have attended the school. Over 60 per cent. have been from the United Kingdom, a quarter from Europe and the rest from the Commonwealth, Asia and the Americas.

Most of the people who attend the school are qualified in some branch of science, medicine or technology. They go to learn about the properties of radioisotopes and how to use them to advantage in their own particular line of work. In recent years short courses of instruction aimed at laymen with responsible executive positions in industry have been introduced and later this year a course specially for senior trade union officials is to be held.

The greatest users of radioisotopes are workers in medicine and research. There is however an enormous potential for radioisotopes in industry. They provide a cheap, safe and effective tool with a wide range of applications. Many firms and organizations already take advantage of them, but on the whole British industry is slow at adopting new techniques.

The aim of the executive course which lasts for four days, is to introduce the businessman to the properties, applications and benefits of radioisotopes and to impress upon him that handled properly, they constitute less of a hazard than many other industrial processes and techniques. Six such courses have been held to date and all have been well attended—a total of 350 directors from nearly as many firms.

The school management feel, however, that perhaps greater industrial use of radioisotopes could be hastened by also tackling the employee side of industry—hence the trade union course.

Staple diet of the school is the four-week general isotope course. Made up of 30 per cent. lectures and 70 per cent. practical work it is intended to provide technically qualified people with useful background training. On this course, graduates fresh from university find themselves rubbing shoulders with heads of research departments and professors.

Lectures introduce the students to nuclear physics and radiochemistry and give information about measuring instruments and radiological protection. Specialized lectures are

also given on such subjects as industrial applications, gamma radiography and the effects of large radiation sources.

The practical work gives students experience in the handling of radioactive materials and the use of geiger, proportional, gas and scintillation counting equipment. Exercises are given to illustrate the properties of radiation and radioactive materials and techniques such as radioactivation analyses, chromatography, gamma scintillation spectrometry, autoradiography and gamma radiography. Students are encouraged to discuss projects they have in mind and to carry out short investigations of their own choosing.

The course also includes visits to installations at Harwell, the adjoining Wantage Radiation Laboratories and the Radiochemical Centre, Amersham. For medical students a visit to a hospital at Oxford using radioisotopes is laid on.

Since the inception of the school 60 general courses have been held—the 61st is scheduled for June 20th to July 15th and two more at the end of the year. Over 1,000 students have attended the course.

Other courses provided at the school are more or less of a specialized or advanced nature. There is, for instance, the four-day course on radiological protection meant for users of radioactive sources who are not necessarily using radioactive materials in a laboratory. Then there is the Medical Course intended for qualified medical men. After three weeks theoretical and practical work at the school students spend a further three weeks visiting hospitals where radioisotopes are in regular use. They are thus able to get familiar with a wide range of medical applications and hear first hand from people already making use of them.

Programme for July-December, 1960

		£	s.	d.
June 20th—July 15th	General Isotope Course	60	0	0
July 18th—July 22nd	Autoradiography for biologists	15	0	0
July 18th—July 29th	Radioisotope Methods in Analytical Chemistry ..	30	0	0
Sept. 12th—Sept. 16th	Radiological Protection	15	0	0
Sept. 20th—Sept. 23rd	Course for Senior Trades Union Officials			
Sept. 26th—Oct. 7th	Radiochemistry Course	30	0	0
Oct. 17th—Nov. 11th	General Isotope Course	60	0	0
Nov. 21st—Dec. 16th	General Isotope Course	60	0	0

(*The price in pounds refers to tuition fees*)

Courses on the radiochemistry, radiobiochemistry, physics and measurement, and analytical chemistry are also held. In addition there have been special courses for members of the International Labour Office, the World Health Organization and the Association of Water Chemists. One course has been given to science teachers in technical colleges and another was devoted entirely to isotopes in engineering.

Book Well Ahead

Tuition fees for the courses are at present based on a standard rate of £3/day. Students do not have to be sponsored, and the only delay they might experience in being accepted for a course would be due to the fact that courses are usually booked up many months ahead.

Living accommodation for students during the length of a course is usually found in hotels situated in the neighbouring country. Free transport is provided between the hotels and school.

In arranging accommodation the school often sees to it that there is an intermingling of nationalities and of professions in the various hotels. Such intermingling is also encouraged in practical work undertaken at the school.

It is not possible to assess completely the value of the courses to the people who have taken them. There are very clear indications, however, that what the school teaches is

(*Continued on page 336*)

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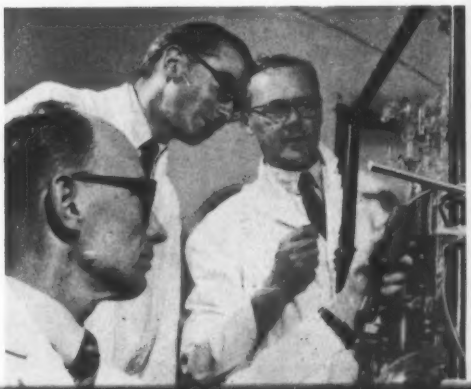


(*Above*) **Students being shown control desk of Harwell reactor.** (*Top right*) **Student gains experience with counting apparatus.** (*Bottom right*) **Mr. R. A. Faires** (*right*) **principal of the school, explains to two students gas counting of C-14**

Westminster talks about...

by Peter Lewis — Our Parliamentary Correspondent

SUMMITS come, and, as we have seen, Summits even more rapidly go, but the procedure of the House goes on for ever. Parliament jealously guards her ancient privileges and the intransigence of Russian statesmen must wait upon the House. This innate sense of proportion does much to gain the world's respect for our stability in times of crisis.

Isotope Transport ....

Possible crises of a more personal nature, arising from the transportation of dangerous isotopes, brought forth a question from **Mr. Hector Hughes** (L., Aberdeen N.) who wanted to know what obligations the Minister for Science had laid down for the guidance of those involved in such hazardous work. **Mr. Derek Walker-Smith,** the Minister of Health, replying for the Minister for Science, asked Mr. Hughes that as the statement on this subject was a very lengthy one, would he be good enough to study it. It was indeed lengthy but, as the Minister pointed out, adequately covered the subject.

U.K.A.E.A. Contract ....

Mr. Frederick Lee (L., Newton) asked **Sir David Eccles,** in his role of Minister for Science, whether he approved the terms of a contract, estimated at £1,750,000 entered into by the Atomic Energy Authority with an unnamed chemical manufacturer, to supply a chemical unobtainable in bulk from any other firm, on conditions guaranteeing a 17 per cent. minimum profit in the first year rising to 45 per cent. in the fifth. This searching question was countered by a reply which boiled down to the fact that the Public Accounts Committee were looking into the matter and Sir David hoped that the House would await that committee's remarks.

That Contract Again ....

Sir David's hopes were in vain for twice in the next fortnight **Mr. William Warbey** (L., Ashfield) asked pertinent questions on the matter. He requested that the President of the Board of Trade, **Mr. Maudling,** refer the terms and conditions of supply of this essential chemical to the Monopolies Commission, to which Mr. Maudling replied in the same vein as Sir David, namely that he would await the report of the Public Accounts Committee. A supplementary question by Mr. Warbey gave further details of the conditions of the case and confirmed his opinion that it was a matter for the Monopolies Commission. Mr. Maudling answered by saying that he was waiting to hear the other side of the case.

.... and Yet Again

In an exchange with Sir David Eccles a week later, Mr. Warbey wanted to know if the AEA could obtain the chemicals mentioned on what he described as less onerous terms, and would the Minister name the company. Sir David did not accept the rather forceful opinions Mr. Warbey had expressed on the matter, but stated that the company was the Imperial Chemical Industries. Later in the month Sir David assured Mr. Lee that he had been advised that no other source was known either in this country or abroad, for the supply of the chemical in question.

N-Merchant Ship

Mr. Marples, the Minister of Transport, faced a barrage of questions on marine nuclear propulsion starting with **Mr. E. L. Mallalieu** (L., Brigg), who wished to know what steps had been taken to ensure that Britain had a nuclear-powered merchant ship at sea at the earliest possible moment. Mr. Marples said that he had invited tenders from five firms for two types of reactor suitable for a tanker of 65,000 tons dead weight.

America v. Britain

Mr. Mallalieu asked if the Minister was satisfied that we should be able to put such a vessel to sea as soon as our competitors. Mr. Marples thought that the Americans would be first.

Money for N-Ship

Mr. Shinwell (L., Easington) wanted to know if the ship would be built at Government expense or by private ship owners or builders, and if the latter, had the Minister any idea where they would get the money. Mr. Marples stressed that it was all a case of first things first, and the first object in this case was to see the results of the tenders. Then followed a protracted argument with **Mr. Gaitskell** using his privilege as Leader of the Opposition, to intervene and ask questions not put down. The Opposition members were obviously concerned about whether the Government were going to indulge in some nefarious scheme whereby they financed the initial building of a nuclear-powered vessel and then when it had proved an economic proposition, hand it over to private enterprise to complete. Mr. Marples repeated that no expenditure at all had yet been contemplated and referred members to the debate raised on March 21st by **Dame Irene Ward** (C., Tynemouth), and that lady being present, she reminded members that the whole idea was to ascertain the possibilities of a commercial venture.

Money for Industry

In a written reply to Dame Irene Ward, Sir David Eccles on behalf of the Minister for Science, stated that his noble friend had been advised by the Atomic Energy Authority that expenditure on civil research and development work placed with private industry was about £9m. between August 1st, 1954 and March 31st, 1960.

BOOK REVIEW

Heavy Fan Engineering, published by Keith Blackman Ltd., is designed to show the scope of the "Tornado" range of fan engineering equipment in the large and heavy sizes. Individual sections deal with centrifugal and axial fans, blowers and exhausters, ancillary equipment such as air heaters, dust exhaust and collecting plant, and metal structure and fabrications. A further section provides a brief survey of the manufacturing facilities available at the three Keith Blackman works.

NUCLEAR NEWS

- **U.K.A.E.A. Culham Building Contract** *(This page)*
- **C.E.G.B. Nuclear Power Exhibitions** *(Page 330)*
- **N-Briefs** *(Page 331)*

Culham Contract

A BUILDING contract for the first phase of construction work at the United Kingdom Atomic Energy Authority's new research establishment at Culham, Oxfordshire, has been placed with M. J. Gleeson (Contractors), Ltd. The Culham site is to be developed as a laboratory for research into controlled thermonuclear reactions and plasma physics. Planning approval in outline was granted by the Oxford County Council in January. The first batch of buildings to be erected on the site will accommodate the large facilities needed for ICSE (Intermediate Current Stability Experiment) and its associated services. Further buildings will be added within the next two years or so to accommodate the remainder of the research being transferred to Culham. Construction work on the first buildings, for which planning permission has been received, will start at once.

International Firm

RIO TINTO announces that it has joined forces with the leading German metallurgical group, Deutsche Gold- und Silber-Scheideanstalt (Degussa) to form Nuklear-Chemie und -Metallurgie Gesellschaft m.b.H. (NUKEM). Degussa is the only private manufacturer of nuclear fuel elements in Germany and has had considerable experience in the processing of rare metals and compounds. Mallinckrodt Chemical Works, through its subsidiary, Mallinckrodt Nuclear Corporation, a leading producer of enriched nuclear fuels in the United States, is also a shareholder and has concluded a technical collaboration agreement with NUKEM providing for exchange of information on the processing of nuclear fuel materials. NUKEM will take over the existing research and production programme of the Degussa Nuklear Gruppe. This programme covers a wide range of uranium and thorium processing and fabricating activities related to the nuclear programmes of a number of countries.

U.K.A.E.A.-Industry Tie-up

COLLABORATION and Licence Agreements recently signed between the United Kingdom Atomic Energy Authority and two chemical engineering companies will help British industry to compete for export business in the design and manufacture of radioactive chemical-processing plant. The two companies concerned are W. J. Fraser & Co., Ltd., and Nuclear Chemical Plant, Ltd. These Agreements are the first of their kind since the Authority's decision in 1957 to collaborate with members of the British Chemical Plant Manufacturers' Association who desired to enter the nuclear chemical field. The two companies entered into negotiations with the Authority and the first step was the signing in August, 1958, of Training Agreements. Selected technical staff were sent by each company to the Authority for training in the design and operation of chemical plants in the nuclear field. The Collaboration and Licence Agreements now concluded cover plant and processes connected with the production of uranium metal billets from uranium ore concentrates and the reprocessing of irradiated nuclear fuel elements. There are provisions for extending the scope of the Agreements from time to time. Under the Agreements, the Authority provide in return for royalties:—(1) A licence to the companies under the Authority's wide patent cover in the nuclear chemical field; (2) General advice on technical problems; (3) Assistance in commissioning and specialized training relating to the particular plants to be built by the companies; (4) Further training, when required, of the companies' technical staff; and (5) Information on current and future significant work in the field.

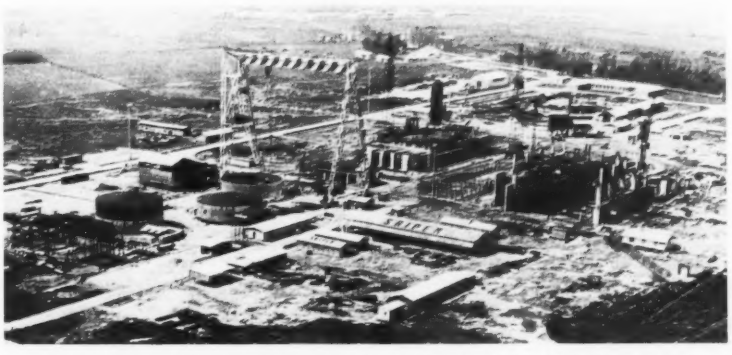
U.K.-German Link

VICKERS, Ltd., of London, and Herr Hans J. Zimmer, of Frankfurt am Main, have announced the formation of the joint enterprise Hans J. Zimmer Aktiengesellschaft Fuer Industrieanlagenbau (Hans J. Zimmer, Ltd., for Industrial Plant Construction) in which each party holds an equal share of the equity. The company will be active in the entire field of plant design, engineering and construction for the chemical and man-made fibre industries. Vickers, Ltd., and Herr Hans J. Zimmer will also hold equal shares in High Polymer and Petrochemical Engineering, Ltd., of London.

Weather Studies

A NATURALLY-occurring radioactive gas has been used as a " tracer " to study how weather conditions affect air pollution in experiments at the Argonne National Laboratory. The gas is radon—a product of radioactive disintegration of radium atoms in the soil. It has been estimated that every square mile of soil to a depth of 6 in. contains approximately 1 gm of radium. As radium steadily disintegrates by emitting alpha particles from its nucleus, it releases tiny amounts of radon through the soil into the atmosphere. The atmosphere contains on the average one part of radon to every 10^{18} parts of air. Scientists in the Meteorology Group of Argonne's Radiological Physics Division measured concentrations of radon in the air each hour during three observation periods totalling 72 hr. This enabled them to observe how varying weather conditions affected the atmosphere's ability to cleanse itself of pollution. They also discovered new information concerning the atmospheric distribution patterns of radon. The test extended from ground level to 130 ft.

Latina Takes Shape



General view of the Latina nuclear power station site, Italy. At the left centre can be seen the third boiler and the pressure vessel welding area. Beneath the Goliath crane is the second boiler being internally cleaned

Wooing the Public

THE Central Electricity Generating Board has been organizing exhibitions in three Kentish towns in order to let the public know why Kent has been chosen as the site for a nuclear power station. The exhibitions portrayed the story of electricity supply. A dramatic graph showed that the demand for power doubles every 10 years. A model of a coal-fired power station, a model transmission tower, and samples of overhead lines and underground cables were among the exhibits. In addition a " Dial a Question " unit broadcast recorded answers about electricity for inquirers. Details were given of the power station at Richborough —now being built—which will eventually burn about half the output of the Kent collieries. The nuclear power station project at Dungeness, the prospects for local employment, the new lighthouse—which has largely been paid for by the Generating Board—and the cross-Channel cable scheme, were illustrated by pictures and models. One section was devoted to the nuclear power station construction programme, and included models of the nuclear power stations already being built.

U.K.A.E.A. P.R. Men at Savoy

Mr. E. Underwood, OBE, Director of Public Relations UKAEA (*right*), with Dr. Horace Manley, UKAEA technical writer, and Mr. R. Truscott, chief press officer, UKAEA, at the recent reception given by Princes Press Ltd., publishers of NUCLEAR ENERGY, **to celebrate the 21st anniversary of their journal,** THE CONSULTING ENGINEER

More U. Processing

MALLINCKRODT Nuclear Corporation, the world's largest commercial processor of uranium fuels, is adding 3,200 sq.ft to its nuclear fuels research facility at the Hematite, Mo., plant and building a new atomic fuels warehouse to replace the space taken over by the growing research and development activities. This third expansion since the plant was built in 1956 brings total space to 2½ times the original, or 40,000 sq.ft, devoted exclusively to commercial production of atomic fuels for research reactors, critical facilities, power reactors and process heat reactors. The Hematite plant, when commercial operation began in 1956, contained 16,000 sq.ft of area. 1957 saw 5,000 sq.ft added, and 1958 another 13,000 sq.ft.

Radiation and Health

A GROUP of eight distinguished radiobiologists from six countries recently met in the Palais des Nations, Geneva, to consider what types of study are most urgently needed to determine the effects of radiation on health and how the World Health Organization (WHO) can be of assistance in this important field. WHO has been concerned with the effects of ionizing radiations on man and the health aspects of the peaceful uses of atomic energy since 1953, Dr. P. M. Kaul told the group when he opened the meeting. He recalled that a programme, which included training of scientific workers, collection and distribution of information, and co-ordination of research, was recommended by a group of experts that the Director-General of the Organization consulted at that time. With the intensification of the WHO medical research programme in recent years, Dr. Kaul said, greater emphasis has been placed on the health problems arising from the rapidly expanding use of ionizing radiations and of fissionable materials for peaceful purposes, and consequently the increasing exposure of man to radiations. Closely connected with these problems are the effects of ionizing radiations on generations unborn, and therefore research in radiation biology and medicine, and human genetics, are a part of this programme.

N-Sub. Sea Trials

THE *Patrick Henry*, the United States' newest and second Polaris missile-firing nuclear submarine, recently successfully completed its initial sea trials. The nuclear reactors for her and her " sister " ship, the *George Washington*, which was commissioned last December, were designed and developed by the Westinghouse-operated Bettis nuclear power laboratory in Pittsburgh under the direction of and in technical co-operation with the Naval Reactors Branch, U.S. Atomic Energy Commission. The Westinghouse Electric Corporation's Sunnyvale, California, manufacturing division designed and built the Polaris launching and handling equipment.

Future of N-Power

THE long-term " need for atomic energy as a source of power remains as great as ever," states the annual report of the International Atomic Energy Agency to the United Nations Economic and Social Council. " If there has been some deferment of short-term expectations," the report points out, " it is probably because earlier appraisals underestimated the seriousness of the technological problems and were unduly influenced by transient economic and political factors." The report, covering the period April 16th, 1959 to April 15th, 1960, says that a solution of the practical problems involved in developing the technology of nuclear power will depend on progress in quite separate branches of science and industry. Advances in metallurgy or electronics in the next few years could, for example, result in important economies in nuclear power generation, and it is possible that the cost of nuclear fuels will fall. In the meantime, the Agency is helping its member states in preparing for the eventual introduction of nuclear power by economic and technical studies, by giving technical assistance to basic atomic activities, by exchange of information through scientific meetings and publications, by training personnel, and by formulating measures to ensure safety in the atomic industry.

German Plant Progress

A DOMED steel cylinder which will house the reactor for West Germany's first nuclear power plant has been completed at the site near Kahl. General Electric is supplying the single-cycle boiling water reactor and the nuclear steam supply system for the plant, scheduled to be in operation late this year. The 15 MW station is being built by the German electrical manufacturer Allgemeine Elektrizitats-Gesellschaft (AEG). The plant will be owned by Rheinisch-Westfaelisches Elektrizitatswerk (RWE), one of Europe's largest utilities, and Bayernwerk (AG), another large utility in West Germany. Versuchsatomkraftwerke (VAK) of Kahl, jointly owned by the two utilities, will run the plant. U.S. General Electric will provide consulting assistance and training for the VAK operators at the plant before the reactor begins working.

N-Service Formed

A GROUP of American nuclear engineers and scientists has formed a new technical service organization called Nuclear Utility Services, Inc., to help electric utility companies plan and operate nuclear power plants. Included in the group is the engineer who directed the design and construction of the pioneer Shippingport atomic power station and co-ordinated all the atomic power activities for Duquesne Light Co., and the scientist who was responsible for the nuclear design of the S5W " Skipjack " atomic submarines.

N-Briefs

Edinburgh University Court has announced the decision to establish a Chair of Electrical Engineering at the University.

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Visitors to the recent Instruments, Electronics and Automation Exhibition at Olympia, London, totalled 75,276. Of these, 4,015 were from 61 different overseas countries.

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William Boby & Co., Ltd., water treatment engineers of Rickmansworth, Herts, have been awarded a contract valued at £3,500 for demineralization plant by the United Kingdom Atomic Energy Authority at Harwell.

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The protection of workers against ionizing radiations is being considered at the 44th Session of the International Labour Conference being held at Geneva. A new convention and recommendation on this subject are likely to result.

* * *

A symposium on nuclear reactor containment buildings and pressure vessels recently organized by the Royal College of Science and Technology, Glasgow, was attended by some 250 experts. Among them were about 100 visitors from overseas, representing 16 countries.

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An order worth £250,000 for an Orion electronic digital computer has been placed with Ferranti Ltd., by the National Institute for Research in Nuclear Science. The computer will be installed at the Institute's Rutherford High Energy Laboratory at Harwell.

* * *

Britain can boast the largest integrated electricity supply system in the world. How this system has come about with the centralization of control of hundreds of power stations throughout the country—even before nationalization—is outlined in a booklet called " Pattern of Power " issued by the Central Electricity Generating Board.

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Leading scientists from 33 countries and several international organizations have been meeting in Vienna for a symposium on radiation dosimetry organized by the International Atomic Energy Agency. They discussed a number of selected topics concerning the methods and instruments for the measurement of radiation doses.

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Nuclear physics and radiation laboratories are to be included in the new Paisley Technical College. They will require to be approved by the appropriate authorities and will be the first to be established in an educational centre in Scotland apart from the Glasgow University Nuclear Physics laboratory.

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A saving of £2,690,000 in fuel costs was made by the Central Electricity Generating Board during 1959 due to improved efficiency of the generating plant. The overall average thermal efficiency of the power stations operated by the Board was 26.36 per cent. during the 12 months of 1959, compared with 25.99 per cent. for the previous year. The 20 most efficient stations had an average efficiency of 30.67 per cent., the highest being attained by Blyth "A" station (33.88 per cent.).

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Mallinckrodt Nuclear Corporation of St. Louis, U.S.A. have received a contract from Argonne National Laboratory, Lemont, Ill., calling for 1,200 kg of highly enriched uranium metal. The major portion of the metal will be used in the core of the fast reactor ZPR-6. This is a new experimental reactor designed to investigate various fuel configurations and the effect of these fuels on various materials being considered for use in reactor construction. Production has already begun at Mallinckrodt's Hematite, Mo., plant.

* * *

An Indian Atomic Energy Commission delegation has been visiting the U.S.S.R. at the invitation of the Soviet Government to discuss Indo-Soviet co-operation in the peaceful uses of nuclear energy. The visit is a follow-up of the visit to India early this year by the head of the atomic energy board of the U.S.S.R. Council of Ministers and other Soviet nuclear energy scientists. The Indian delegation is expected to visit the U.S.A. later this year to finalise an Indo-U.S. Nuclear Power agreement which will help India to implement her programme of constructing small power stations with an aggregate capacity of 1m. kW besides the first power station in the Bombay-Ahmedbad region.

Anti-Radiation Work

SCIENTISTS have shown for the first time how certain chemical compounds protect living cells against the effects of radiation, in experiments at the Argonne National Laboratory. The anti-radiation compounds are sulphydryls (SH), so named because their active group contains sulphur and hydrogen. One of the most effective members of this group in preventing radiation damage in mammals is cysteine, an amino acid present in all protoplasm, a fundamental building block of living tissue. Argonne's research indicates that the sulphydryls work by reducing the lethal potency of a combination of oxygen and chemically active molecule fragments which team up to cause radiation damage in cells. These fragments—called free radicals—are produced by radiation. They are pieces of molecules that are chemically highly reactive, usually combining with essential components of cells. The net result is that a healthy cell may become abnormal or die. Scientists have known for some time that the presence of oxygen in living systems increases the sensitivity of the cells to radiation. However, they did not know the nature of this effect, nor did they have any critical evidence of a link between oxygen and the action of protective compounds. Researchers had proposed that SH compounds work by consuming oxygen in the system, thereby reducing the concentration of oxygen and reducing radiation sensitivity. Argonne's work, in addition, is a direct demonstration that SH compounds also function by removing free radicals, which, in the presence of O, would be toxic.

Plastic Lead used in N-Energy

OF special interest to scientists and engineers working in the nuclear field is " Devcon L," the plastic lead. Similar in many respects to plastic steel, it is made by the same manufacturer. It comprises approximately 94 per cent. lead and 6 per cent. of a special thermo-setting plastic, has the consistency of putty, and can be moulded to shape as easily as can modelling clay. No heat, pressure or flame is required in applying it. Three hours after the addition of a special hardening agent, the mixture becomes tough and rigid,

Once hardened, the " Devcon L" can be sawn, drilled or machined with regular tools. It can be pounded or shaped with a hammer, and its index of malleability is identical, for all practical purposes, with that of lead.

Developed originally for repairing lead-lined tanks and miscellaneous equipment used by the chemical and allied industries, " Devcon L " was enthusiastically adopted in place of the conventional " lead burning." Its use, whether for repair or construction, has proved less expensive, less time-consuming and decidedly less dangerous than the traditional methods. This is because neither heat nor flame has to be employed to work it.

One chemical company constructed a new lead tank by simply trowelling " Devcon L " on the inside of a large wooden tank! The same company used " Devcon L " for bonding lead sheet to the inside of a cast-iron and steel cylinder.

" Devcon L " is also used for the splicing and repair of lead-covered cables, such as are used by public utility and telephone companies, as well as for general maintenance work. It has excellent adherence to lead, aluminium, bronze, brass, wood, cast-iron, porcelain, concrete and can be used to bond these materials either to themselves or to each other.

Shrinkage is negligible during hardening: never more than of the order of 0.0005 in. It has high impact, compression and tensile strengths. It is resistant to most inflammable or volatile solvents. What is more, " Devcon L " can be stored almost indefinitely, and does not harden with age. Only the addition of the special hardening agent will " set " the " Devcon L."

In the field of nuclear energy, " Devcon L " has been used in the most striking fashion. The ease, speed and safety with which " Devcon L " can be handled and applied make it the ideal material for providing shielding against radioactive substances, especially at those times when that shielding has to be provided within definite time limits. And what is more, because of its extreme ductility, the plastic lead can be moulded exactly to any shape required. " Devcon L " is marketed in this country by E. P. Barrus (Concessionnaires), Ltd., of London, W.3.

PEOPLE... in the NUCLEAR NEWS

A man with " a very wide knowledge of radiochemistry, perhaps with the widest in England " is how Dr. Henry Seligman, deputy director general of the International Atomic Energy Agency in charge of Research and Isotopes, describes **DR. GERALD B. COOK,** newly appointed chief chemist to the Agency. Dr. Cook is certainly an expert in his field, having been closely connected with chemistry aspects of

Dr. G. B. Cook

atomic energy development for 20 years. A graduate of Birmingham and Cambridge universities, he worked for three years on the Canadian atomic energy project in Montreal and at Chalk River. In 1947 he returned to England and joined the Chemistry Division at Harwell. Seven years later he was appointed head of the chemistry group of the Isotope Research Division, which at that time was headed by Dr. Seligman. Dr. Cook is part author of the widely used textbook, " Modern Radiochemical Practice " and he has contributed some 40 scientific papers on various aspects of radiochemistry.

PROFESSOR CARLO SALVETTI, the newly appointed director of the Research and Laboratories Division of the International Atomic Energy Agency, has had a distinguished career in the field of nuclear physics. Before joining the Agency he was director-general of the Italian Government's nuclear research centre ISPRA on Lake Maggiore, and played an important part in the establishment and development of the centre. He has been associated with Milan University for many years and has also taken an active part in the work of the European Nuclear Energy Agency (OEEC). From 1946 to 1957 he headed the pioneer reactor group laboratory, CISE, in Milan.

DR. P. R. HOWARD, has been appointed head of the High Voltage Laboratories at the Central Electricity Research Laboratories, Leatherhead. He will be assisted by **MR. D. F. OAKESHOTT,** who has been appointed deputy head.

DR. R. L. P. BERRY, ICI Beryllium Project Manager, has been appointed to the Board of ICI Metals Division. Dr. Berry, who has been projects manager since 1958, joined ICI in 1936. After working in the research department of the Metals Division carrying out post-graduate work on behalf of the company in the School of Metallurgy, Birmingham University, with war service in the Royal Engineers and five years at university sandwiched between, Dr. Berry resumed full-time service with ICI Metals in 1951. Since then he has been primarily concerned with the development of " new " metals. Dr. Berry also joins the delegate boards of the ICI subsidiary companies, Marston Excelsior, Ltd., and Lightning Fasteners, Ltd.

The new head of the Harwell Isotope Research Division is **MR. B. S. SMITH,** formerly head of the Health Physics Division. An old Mill Hillian and graduate of King's College, London, Mr. Smith was for five years a demonstrator in physics at Kings. From 1939-44 he was engaged in radar development. He then went to Canada to assist in the development of

Mr. B. S. Smith

Mr. N. G. Stewart

instrumentation for the NRX reactor at Chalk River. He returned to the United Kingdom in 1948 to join the Nuclear Physics Division at Harwell. He is succeeded in his former post as head of health physics by **MR. N. G. STEWART,** who is at present in charge of the health and safety division at Dounreay. Mr. Stewart takes up his new duties in August. A former university and school teacher, he was also engaged in radar development during the war years. He joined the UKAEA in 1948 and until 1958 was group leader in the health physics division at Harwell.

MR. M. L. JOFEH, OBE, AMIEE, who was recently appointed an additional director of Sperry Gyroscope, Ltd., joined the company in 1947 as an equipment engineer. For several years he headed the engineering unit at the company's Stonehouse (Glos.) factory. In 1954 he returned to headquarters to become deputy chief engineer and then chief engineer. January of last year saw him appointed as manager of the company's industrial division.

New deputy chairman of the chemical group of the Distillers Company is **MR. G. F. ASHFORD.** New managing director of the Chemical Division is **MR. J. H. DUNN.** He succeeded **MR. J. M. RIMINGTON** who recently retired after 30 years' service.

The Institution of Works Managers has appointed an education officer to collaborate with technical colleges in the running of the Institution's two-year training courses. He is **MR. LAWRENCE SUTTON,** BSc(Econ), formerly director of studies at Ashridge College. Educated at Eastbourne College, University College, London, and the London School of Economics. He joined Ashridge College in 1931 as senior tutor. After wartime service with the Royal Engineers he was with the Education Branch of the Control Commission for Germany from 1945 to 1950. His first task was to remove the Nazi associations in the University of Goettingen, and reopen it with its liberal traditions restored. He returned to Ashridge College in 1950.

The Engineering Group of the General Electric Company, Ltd., of England, have appointed **MR. E. W. MOLESWORTH** as chief engineer for the London, Southern and Eastern Areas. Mr. Molesworth, who has been with the company for over 30 years, succeeds Mr. C. J. O. Garrard who was recently appointed assistant general manager of the Erith Engineering Works (NUCLEAR ENERGY, May, 1960). The new deputy engineer of the same territory is **MR. J. L. ORME,** AMIEE, who has been with GEC since 1920 when he was an apprentice. After joining the company he was given a scholarship to work at Birmingham University.

DR. A. J. P. MARTIN, CBE, has retired from the board of Griffin & George (Research & Developments) Ltd. He is to be retained by the company in the capacity of consultant and is succeeded as director of research by **MR. R. C. PALMER,** MA (Cantab), his deputy. Mr. Palmer, MA, was born in 1912, and educated at Mostyn House School and Worksop College, Notts., and Cambridge University. He was on the staff of the Wool Industries Research Association, Leeds, from 1937 to 1951. He was then appointed director of research of the South African Wool Industrial Research Institute. He joined Griffin & George (Research & Development) Ltd., in 1960.

MR. C. J. ATKINS, sales director of Keith Blackman Ltd., and **MR. F. W. GOODGE,** contracts director, have been appointed joint assistant managing directors of the firm. Other new appointments at Keith Blackman include the following:— **MR. F. W. BROWN,** as commercial manager; **MR. E. A. MANNING,** V Dept. manager; **MR. R. F. WILLIAMSON,** contracts manager and **MR. P. C. BURDEN,** chief draughtsman (contracts).

RADIOISOTOPES AID U.S. RAILROADS

One Company Saves £150,000 a Year

A survey of the application of nuclear energy and radioisotopes to the railroads and of associated research was given at the recently held Western Industrial Radioisotopes Conference, San Francisco, by Mr. A. S. Pedrick, assistant manager of Research and Development, the Southern Pacific Co., San Francisco. He dealt with the long term research studies conducted by the Association of American Railroads and then with individual work of some of the railroads. He concluded with a detailed description of work carried out by his own company. This article is based, with Mr. Pedrick's approval, on his paper.

IN one application alone radioisotopes are saving one American railway company, or railroad, an estimated $400,000 (£150,000) a year. The isotopes have been used to study the effect of different lubricants, fuels, etc., on the performance and wear of various locomotive engine parts. As a result improvements have been applied to some 161 motive units leading to reduced maintenance and operation costs. Further saving, so far unaccounted for, is brought about through the greater availability of the locomotives due to their being out of service for repairs less often.

This is just one of the ways American railroads are benefiting from the peaceful practical application of nuclear energy. The same company has for instance been using radioisotopes for radiographic inspection of steel castings since 1951, while there have been several applications of radioactive tracer techniques to evaluate among other things the properties of soaps and detergents and the worthiness of electrical cable insulation. Studies have also been made of the possibilities of nuclear powered locomotives and of the use of radioactive lamps.

Some of the investigations and studies leading to the isotopic innovations have been made by the railroads individually. Other work has been carried out on a co-operative basis at the Association of American Railroads' Research Centre, Chicago. One of the facilities at this centre is an isotopes laboratory at which various isotopes are available for tracer studies with oil and other petroleum products.

Food Preservation

With the Radiation Division of the United States Army Quartermaster Corps the Association is carrying out an investigation into the radiation of foods and vegetables. If it is found possible to increase the storage life of these perishables without the use of refrigeration the railroads will reap considerable benefits.

In 1958 the Association asked the Armour Research Foundation to study the potentialities of nuclear light sources for signals, switch lights, etc. It was found that the most likely method of obtaining sufficient illumination in a practical method was to use a suitable isotope —such as krypton-58—in conjunction with a compacted phosphor. Such combinations will provide a lamp that will remain illuminated for several years without even having to be replenished or tended. The advantages are obvious.

Nuclear powered locomotives are at the moment considered impractical. Operational costs would be high, as also would be risks of accidents. Studies made have indicated that the most feasible application of nuclear power for propulsion would be to supply the locomotives with electricity generated from a large central plant.

More immediate in its practicability has been the gamma densometer developed by the New York Central System to evaluate the quality of cross ties in railroad track. The equipment utilizes the Compton scattering of gamma rays.

For an incident, gamma ray of a given energy, the energy of the scattered gamma ray is a function of the angle at which it is scattered. Also the intensity of the back scattered radiation is a function of the electron density of the material. Thus, those gamma rays scattered in a backward direction will lie in a certain energy band and if an energy selective detector is so set that only those gamma rays in the vicinity of this band are measured, the response of the detector will be primarily due to the gamma rays that are scattered back from the medium. It is claimed that the device currently developed readily determines the difference in densities between serviceable and unserviceable ties. Caesium-137 is used as the gamma ray source.

Cleaning Tests

Another isotope—chromium-51—has been used by the New York Central System to evaluate the properties of soaps and detergents in removing chromate soils from the skins of employees who work on and around diesel locomotives using chromate type water treatment. Employing the isotope as a tracer, the experiments were carried out on white rats.

Radioactive tracer techniques were also used to find out the resistance

IN BRITAIN

The British Transport Commission are not so enthusiastic about the use of radioisotopes as some of the American railroads appear to be. Radioactive sources are used to a limited extent by British Railways for non-destructive testing, and this application will be extended where it would seem to be advantageous. No use is yet made of radioisotopes, however, for studying engine wear, though the progress being made in America in this particular practice is closely followed.

of electrical cable insulation to water. The insulation was exposed to a soluble carbon-14 tagged compound. Results were then collected over a period of weeks by means of radioactive counts.

The research department of the Denver and Rio Grande Western Railroad has also been active in applying radioisotopes to railroad problems. Their work includes the use of radioactive tin-113, antimony-125, and zinc-65 for study of intergranular penetration of iron in overheated axle journals. They perform radiography of rails using a 20 curie source of iridium-192 and they use a technique of radioactive wear tests on diesel engines which is virtually identical to the work done by the Southern Pacific Co., of San Francisco.

The Wear Tests

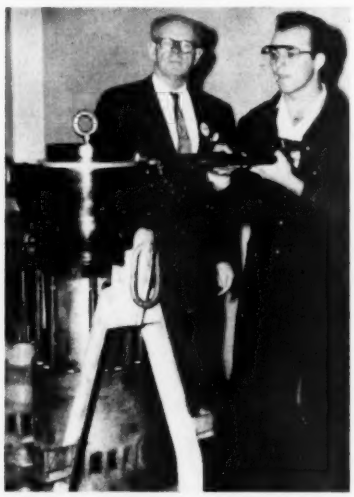
In their research in connection with the use of less costly fuels in diesel locomotives the Southern Pacific Co., in 1948 equipped one of their locomotives with four radioactive piston rings. By means of radioactive tracer techniques they were able to study piston ring wear as influenced by fuels, lubricants, engine operation and selection of engine parts. This study proved so successful that it was extended to evaluate engine air filters, ebullition cooling system and the effect of various contaminants in used lubricating oils.

Standard cast-iron piston rings which were made radioactive by irradiation with neutrons in a nuclear reactor were applied to pistons in two Electro-Motive Division Type-GP-9 locomotives with 16 cylinder Type 567-C engines. Later, in the final phase of the investigation, which was completed last October, radioactive rings were applied to pistons in 16 cylinder Alco Products' Model 244 engines.

SOUTHERN PACIFIC STATISTICS

The Southern Pacific Company operate about 19,000 miles of rail track, including sidings and yard track, covering seven of the southern and west coast states. Rolling stock at the end of last year totalled 2,091 diesel locomotive units, 2 steam locomotives, 80,676 freight wagons, 1,282 passenger-train cars, and 5,134 company service units and cabooses. Revenue during 1959 amounted to $690,316,000. Operating expenses totalled $539,947,000. $90,317,000 was spent on maintenance of track and structures and $142,937,000 on maintenance of equipment.

When piston rings are subjected to irradiation with neutrons in a nuclear reactor some of the atoms of iron-58 absorb neutrons and form radioactive Fe59. The arrangement of protons and neutrons in the nucleus of the atomic structure is changed and the element although retaining the identical chemical properties of iron,



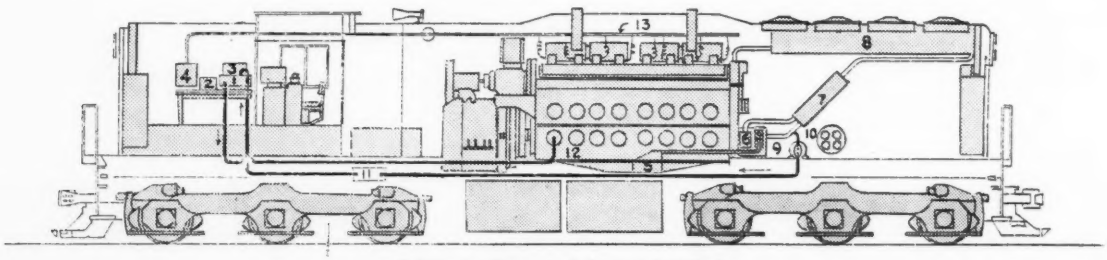
Radioactive ring being installed into a piston groove. To prevent personal contamination the ring expander is equipped with extended handles

is converted to an unstable form and emits gamma and beta radiation with total energy of 1.56 MeV. Half life is 45 days.

Radioactive iron particles worn from the piston rings collect in the crankcase oil and wear is indicated by gamma count as the oil is circulated through a counting well equipped with four Geiger-Muller detectors. The geiger tube counts were registered on a decimal scaler which was connected to a printing clock. The time for each 10,000 counts on the scaler was automatically recorded on the printing clock tape to the nearest one-hundredth of a minute. Counts/sec were plotted against time and is a straight line function for a given power output. Usually 6 hr to 8 hr of operation is sufficient to establish a wear rate.

The actual wear rate in milligrams of iron/hr was obtained by dividing the slope of the counting

Power assembly equipped with radioactive piston rings being swung into position in test locomotive. Preliminary studies of piston wear were made with the loco stationary



Schematic diagram of the test installation

Key: 1—counting well; 2—scaler; 3—recording clock; 4—potentiometer; 5—sump; 6—scavenging oil pump; 7—lube oil cooler; 8—cooling fans; 9—sampling oil pump; 10—by-passed oil filter; 11—sample oil cooler; 12—sample oil return; 13—thermocouple leads

rate curve (rate of increase in radioactivity in the lubricating oil) by the specific activity and multiplying by the ratio of volume of oil in the sump to the volume of oil in the counting well. This is stated by the following equation:

$$\text{Wear rate}\left(\frac{\text{Mg Fe}}{\text{hr}}\right)=\frac{\text{Slope of curve}\ \left(\frac{\text{counts/sec}}{\text{hr}}\right)}{\text{Specific Activity}\ \left(\frac{\text{counts/sec}}{\text{Mg Fe}}\right)}\times\frac{\text{Vol. of oil in sump}}{\text{Vol. of oil in counting well}}$$

The specific activity of the irradiated rings was obtained from a small quantity of iron filed from the back of the irradiated rings prior to their installation in the engine. A weighed portion of these iron filings was dissolved in hydrochloric acid and diluted to the volume of the counting well. The activity in counts/sec of the solution was then obtained at periodic intervals by using a counting chamber identical to the one used on the locomotive. This was plotted against time to give the decay of specific activity curve. Knowing the milligrams of irradiated iron in the solution, it was then a simple matter to determine the counts/sec/mg of iron.

Rings in Progression

Four radioactive piston rings were used in the first application and this was subsequently increased to nine rings and finally 16 rings/engine; placed one/piston in second ring groove. A few applications were made to the first ring groove which provides higher wear but tends to be more erratic than in the second ring groove position. Cylinder bore is $8\frac{1}{2}$ in. in diameter from EMD 567-C engines and 9 in. in diameter for the Alco Model 244. Two reactors have openings of sufficient size to permit irradiation of the rings used in these tests; one at the Argonne National Laboratories in Lemont, Illinois, and the other at Brookhaven National Laboratories on Long Island, New York.

The activation, disintegrations/sec, $A_{d/s}$, obtained by irradiating the piston rings in the nuclear reactor for a period of time, t, may be expressed by the following equation;

$$A_{d/s}=N\sigma\phi(1-e^{-\lambda t})$$

Where: N=target atoms in material being irradiated, σ=microscopic cross section, ϕ=neutron flux, neutrons/cm²/sec, λ=disintegration constant, and e=2.718 (Base of Natural System of logarithms).

General view of test site. In the foreground—testing of engine air filters

Target atoms may be calculated from weight of iron/ring, 200gm; atomic weight 55.85 gm; Avogadro's Number, 6.02×10^{23}; and isotopic abundance factor for Fe58, 0.33 per cent.

Therefore:

$$N=\frac{200}{55.85}\times6.02\times10^{23}\times0.0033$$

$$N=7.10\times10^{21}\ \text{atoms}$$

$$\sigma=0.9\ \text{barn}=0.9\times10^{-24}\text{cm}^2/\text{nucleus}$$

$$\phi\cong5\times10^{12}\ \text{neutrons/cm}^2/\text{sec}$$

$$\lambda=\frac{0.693}{\text{Half life}}=\frac{0.693}{45\ \text{days}}$$

Using these figures along with an irradiation time of 10 days and substituting in the above equation gives a calculated activity:

$A_{d/s}\cong454\times10^7$ disintegrations/sec.

Since 1 millicurie equals 3.7×10^7 disintegration/sec the expected radioactivity/piston ring for the above conditions is:

$$\frac{454\times10^7}{3.7\times10^7}=122\ \text{millicuries}$$

The Radioactivity

Actual radioactivity of the piston rings used in this research project was approximately 100 millicuries/ring at time of application to the engines. The gamma radiation dose at 1 ft distance, assuming a point source is approximately 775 mr/hr. Measured radiation in the engine air box close to the liners after 16 radioactive rings were installed was 600-700 mr/hr. This shows the effect of shielding by the iron in the engine and distribution of activity by having only one radioactive ring on each piston.

Testing ebullition cooling system

Radiation surveys and monitoring were carefully performed to protect all operating, maintenance and test personnel against radiation hazards. There was no difficulty in maintaining radiation exposure well within 100 milliroentgens/week.

Work of assembly and disassembly of power assemblies was carefully planned and rehearsed so that time of exposure to radiation would be reduced to a minimum. The irradiated rings were not touched by hand, but handled with long-handled tongs and applied to piston with a ring expander equipped with extensions.

Stringent Precautions

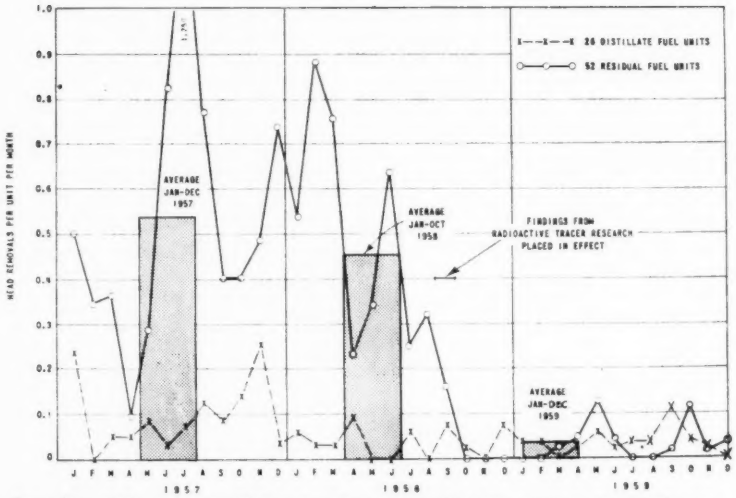
All persons who performed the piston ring and power assembly installations were assigned two dosimeters, one worn on the chest and the other strapped to the man's wrist. The amount of radiation received and measured with the dosimeters was recorded and signed for in a record book by each person.

Results of this research were placed in effect as the tests progressed. There were changes in selection of fuels and lubricating oil for diesel engines to provide reduced wear. Improvements were made to engine air filtration and engine speed was changed from 800 to 835 rev/min for all models of EMD engines. The effect of various contaminants in lubricating oil was evaluated with respect to piston ring wear.

The improvement in reduced number of power assembly replacements and cylinder head removals has been outstanding, especially on the dual fuel units which were equipped to burn residual type fuel at high engine outputs. When the findings from the radioactive tracer research were placed in effect starting in August, 1958, parts replacements and related maintenance work started to reduce at a rapid rate. The results for 1959 indicate annual maintenance and operating savings of approximately $400,000 for the 161 dual fuel units now in service and this does not include a value on improved availability of the locomotives on account of less time out of service for repairs.

Controlled Conditions

Wear measurements obtained under controlled conditions of standing test operation with activated piston rings demonstrated excellent reproducibility of results and correlation with actual wear measurements obtained from prolonged field tests. This application of radioactive isotopes provides a means of determining piston ring wear in a matter of 6 hr to 8 hr for a given set of conditions. It eliminates errors from the many variables which are present when running road service tests.



Some idea of the extent to which savings have been made to the company through the use of radioisotopes is given by this graph. It shows the number of head removals due to valve blows made over the past three years in locomotives engaged on regular mountain freight service. The effectiveness of the radioactive tracer tests is indicated by the noticeable drop in the replacements necessary since the 1958 autumn

Apart from these tests the Southern Pacific Co., has used radioisotopes for radiographic examination of heavy steel castings such as couplers and coupler yokes. The company obtained its first cobalt-60 source for this purpose nine years ago. Strength of it was 620 millicuries. Later a 5 curie source was obtained which cut the radiographic exposure time.

Back to School

(*Continued from page 327*)

generally used to good purpose. A questionnaire sent to all past students, for instance, revealed that 88 per cent. of them were using radioisotopes and most of them had bought British electronic equipment. Many of them had set up active laboratories both at home and abroad and in this connection the school is often asked to advise on proposed laboratory layouts.

Other past students have themselves set up training courses in the use of radioisotopes, particularly in technical colleges, and there are currently about 40 such courses in this country alone and more are planned. Similar courses now being held in centres in Austria, Germany, Italy and Switzerland have also been started by past students.

That students are using information gained at the school for research purposes is indicated by the contributions they make to technical journals.

Contact is often maintained with the school by past students who write in to ask for assistance in problems that emerge in their post school work and many of the enquiries received by the UKAEA Isotope Division's Industrial Advisory Service, the Isotope Information Office and the Radiochemical Centre, Amersham, are made by past students.

There seems little doubt that the school is more than adequately fulfilling the function originally allotted it and that in the future it is likely to extend its scope even further. There is, for instance, a likelihood of there being an extension to the courses for laymen. It has been suggested that one section of the community that could well do with some instruction in radioisotopes are police officials and where better could they receive this than at the Isotope School?

Some of the demand for the provision of teaching in radioisotopes is undoubtedly adequately met by the universities and technical colleges that run their own courses. The Isotope School at Wantage, however, has one supreme advantage over these, the ability to call on the first hand experience of Harwell scientists and to make use of the Harwell facilities. While there is an Atomic Energy Research Establishment at Harwell there is bound to be an Isotope School.

Book Reviews

Radioisotope Techniques, by R. T. Overman and H. M. Clark. Published by McGraw-Hill Publishing Co., Ltd. Size 6 in. × 9¼ in. × 476 pp.

This book has been written against a background of teaching and is clearly most suitable as a textbook for a course of instruction. The detailing at several stages of laboratory experiments is particularly of great value to those running courses on radioisotope techniques. It is indeed a reassuring feature of the book that the authors have a practical outlook. Long experience in teaching the subject shows itself in the guidance given to avoid errors which are not at all obvious to the uninitiated. The scope of the book, however, is limited to basic theory and practice and does not embrace in any detail those applications which use sources greater than the millicurie level. The treatment of the health physics aspects of the work is broad and realistic and includes useful figures admittedly derived from authoritative publications, such as dosages likely to occur in conditions following a nuclear explosion. The references are numerous but are centred in vintage towards the beginning of the last decade. While this may be satisfactory for the academic aspects of the subject it means no mention is made of the many important developments that have been made in industrial applications during the last few years. The treatment of errors in making measurements of radioactivity is thorough and clearly set out, and the chapter dealing with the preparation of sources for laboratory work is good. The chapter on the standardization of radioactive sources is useful in that it gives the reader a clear idea of the limitations which are involved. Taken as a whole this book is very good and can certainly be recommended to those seeking the finer points of radioisotope techniques.

S. JEFFERSON,
UKAEA, Wantage.

Who's Who in Atoms—1960 Edition. Advisory Editor, A. W. Haslett. Published by Vallance Press, London. Two Volumes. Each 10 in. × 6 in. × 1¾ in. (about 480 pp.). Price £10 10*s.* (two volumes).

Biographical details of over 12,500 scientists and engineers engaged in activities connected with nuclear energy matters in all parts of the world are included in this second and larger edition. There were 8,500 entries in the first edition and they were all contained within the cover of one volume. The increase in entries together with the inclusion of some 300 cross-references (used where names are double-barrelled or have prefixes such as von, van, de, etc.), has necessitated two volumes. More than 70 countries are represented, including Russia and China, and there are entries for men such as Fuchs and Pontecorvo. Leaders in research and development, professors and university teachers, administrators and secretaries of scientific bodies, engineers working on reactor construction projects, editors of nuclear journals, even laymen who promote interest in nuclear matters are all included. Most entries give details of education, principal posts held, special interests, and published work and address. A useful new feature is the pinpointing of the particular interests of the entrants. So often it is not possible to tell the nature of a person's interests in his subject even from the titles of work he has published and this new feature overcomes this uncertainty. While there are bound to be omissions and perhaps inaccuracies in such a large and reputedly comprehensive book as this, the lack of reference to Nuclear Power Plant Co. Ltd. engineers seems curious considering engineers of the other consortia are mentioned. On the whole these two volumes will be a useful addition to the nuclear reference shelves.

Fads and Fallacies in the Name of Science, by Martin Gardner Published by Dover Publications Inc., New York (Constable & Co., Ltd., in the U.K.). Size 8 in. × 5½ in. × 364 pp. Price 12*s.* 0*d.*

This is an entertaining account of the many pseudo-scientific cults and theories that have been put forward from time to time, including the several cases made out against the Laws of Relativity and the remarkable story of the doyen of anti-science groups, the Fort Society. All sciences are covered—medicine, biology, psychology, geology, anthropology, neurology, just to mention a few. One of the most scandalous episodes in scientific history—the Lysenko affair in which accepted and proved scientific principles were completely rejected purely for political reasons—is fully recounted and there is a chapter on the startling flying saucer scare that hit America in the late 40s. This book is fully recommended to anybody who likes to read about cranks, frauds and just simple harmless eccentrics.

British Nuclear Reactors, by Gerald Gibbons and Kenneth Kay. Published by Chatto and Windus. Size 8½ in. × 6 in. × 32 pp. Price 6*s.* 6*d.*

A very simple account of the principles of atomic energy and how they are applied to the harnessing of power. The Calder Hall type of reactor, the Dounreay fast breeder reactor and ZETA are explained. Coloured sectioned drawings abound. A useful book for the schoolchild.

TRADE LITERATURE

An Introduction to Wiggin Nickel-Alloys, published by Henry Wiggin and Co., Ltd., illustrates the technical applications of high-nickel alloys and introduces the reader to the company. High-nickel alloys can be divided into four categories, corrosion-resistant, heat-resistant, electrical-resistance and materials with special properties. The first part of the publication is devoted to these properties of the alloys, it explains how they are assessed and into which groups the company's products fall. The latter part illustrates some actual applications of Wiggin high-nickel alloys and by reading this section one can appreciate the wide field of applications they have found in modern industry.

Other Books and Literature Received

Mechanical World Year Book—1960. Useful data for engineers, together with a classified buyers guide. Size 6 in. × 4 in. × 362 pp. Published by Emmott & Co., Ltd. Price 5*s.* 0*d.*

Mechanical World Electrical Year Book—1960. Useful data for the electrical engineer. Size 6 in. × 4 in. × 246 pp. Published by Emmott & Co., Ltd. Price 4*s.* 0*d.*

Nuclear Reactor Stability, by A. Hitchcock. Size 8½ in. × 5½ in. × 62 pp. Published by Temple Press Ltd. Price 12*s.* 6*d.*

Approaches to Thermonuclear Power, by R. F. Saxe. Size 8½ in. × 5½ in. × 66 pp. Published by Temple Press Ltd. Price 12*s.* 6*d.*

Heat Transfer in the Boiling of Water in Conditions of Forced Circulation, by E. K. Averin and G. N. Kruzhlin. Translated from the Russian by J. B. Sykes. Published by UKAEA. Ref. AERE Trans. 847. Available at Harwell Library.

The Nuclear Absorption Cross Section for Gamma Rays between 10 and 30 MeV, by B. Ziegler. Translated from the German by E. Franklin. Published by UKAEA. Ref. Trans. 839. Available at Harwell Library.

The Kinetic Theory of and Ionized Gas, by W. Marshall. Published by AERE, Harwell. Ref. AERE T/R 2247. Available from H.M. Stationery Office. Price 8*s.* 0*d.*

Environmental Survey from the Air, by A. D. Williams and R. S. Cambray. Published by AERE, Harwell. Ref. AERE—R.2954. Available from H.M. Stationery Office. Price 8*s.* 0*d.*

The Measurement of U238:U235 Fission Ratios, by M. D. Carter, A. J. Perks, and L. G. Saunders. Published by AERE Harwell. Ref: AERE—R.3205. Available from H.M. Stationery Office. Price 4*s.* 6*d.*

The Structure of Magnetohydrodynamic Shocks, by W. Marshall. Published by AERE, Harwell. Ref. AERE T/R 1718. Available from H.M. Stationery Office. Price 5*s.* 6*d.*

Bio-Assay of Excreta and Body Burden of Radioactive Materials. by H. Katharine Williams. Published by AERE, Harwell. Ref. AERE—R.3288. Available from H.M. Stationery Office. Price 3*s.* 0*d.*

Detection of Gamma Radiation by Induced Conductivity, by C. G. Clayton. Published by AERE, Harwell, Ref. AERE—R.3289. Available from H.M. Stationery Office. Price 4*s.* 0*d.*

The Stability of Twisted Magnetic Fields in a Fluid with Finite Electrical Conductivity. 2. Special Results by R. J. Taylor. Published by AERE, Harwell. Ref. AERE—R. 3229. Available from H.M. Stationery Office. Price 4*s.* 6*d.*

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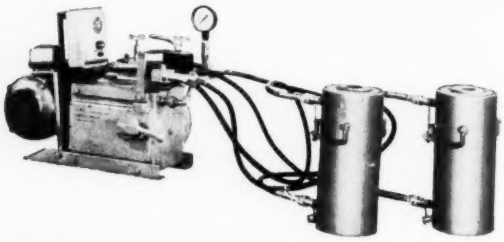

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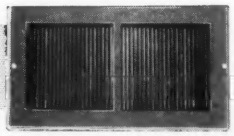

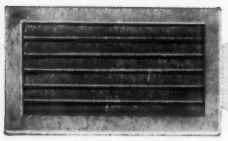

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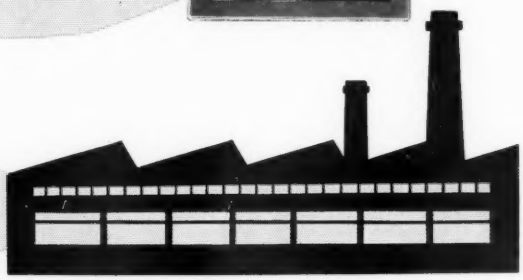

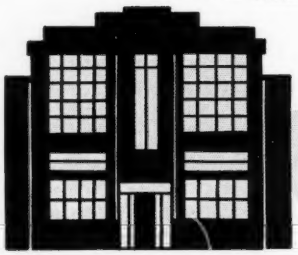

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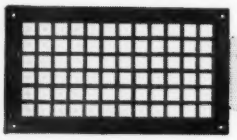

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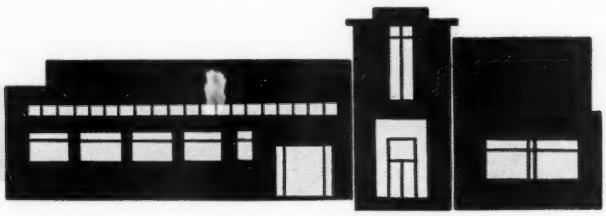

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VOKES GENSPRING have been awarded contracts for the supply of pipe suspension equipment for all current Nuclear Power Stations

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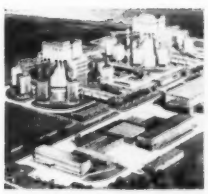

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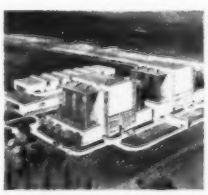

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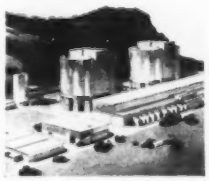

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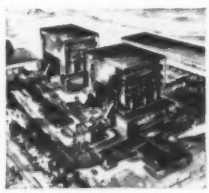

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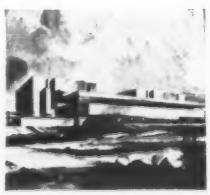

TRAWSFYNYDD
(Atomic Power Constructions Ltd.)

(An impression by Mr. Basil Spence, Consultant Architect to Nuclear Civil Constructors, showing how the design blends into the landscape of Snowdonia)

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